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EARLY ASTOGENY IN *HIPPOPODINA FEEGEENSIS* (BUSK) (Polyzoa–Ascophora)

By N. A. Powell

RÉSUMÉ

L'astogénie primitive de l'*Hippopodina feegeensis* diffère en sa description et son être du type bourgeonnant ordinaire cheilostome parce qu'elle engendre à la première génération deux zoécies provenant d'une façon proximale de l'ancestrula distal: la première zoécie produit un quatrième membre proximal, formant ainsi une structure tétrade distincte. A cause de la ressemblance morphologique entre les membres à ce stade de croissance, il n'a pas été possible de distinguer l'ancestrula tant qu'on n'a pas examiné des stades encore antérieurs.

SUMMARY

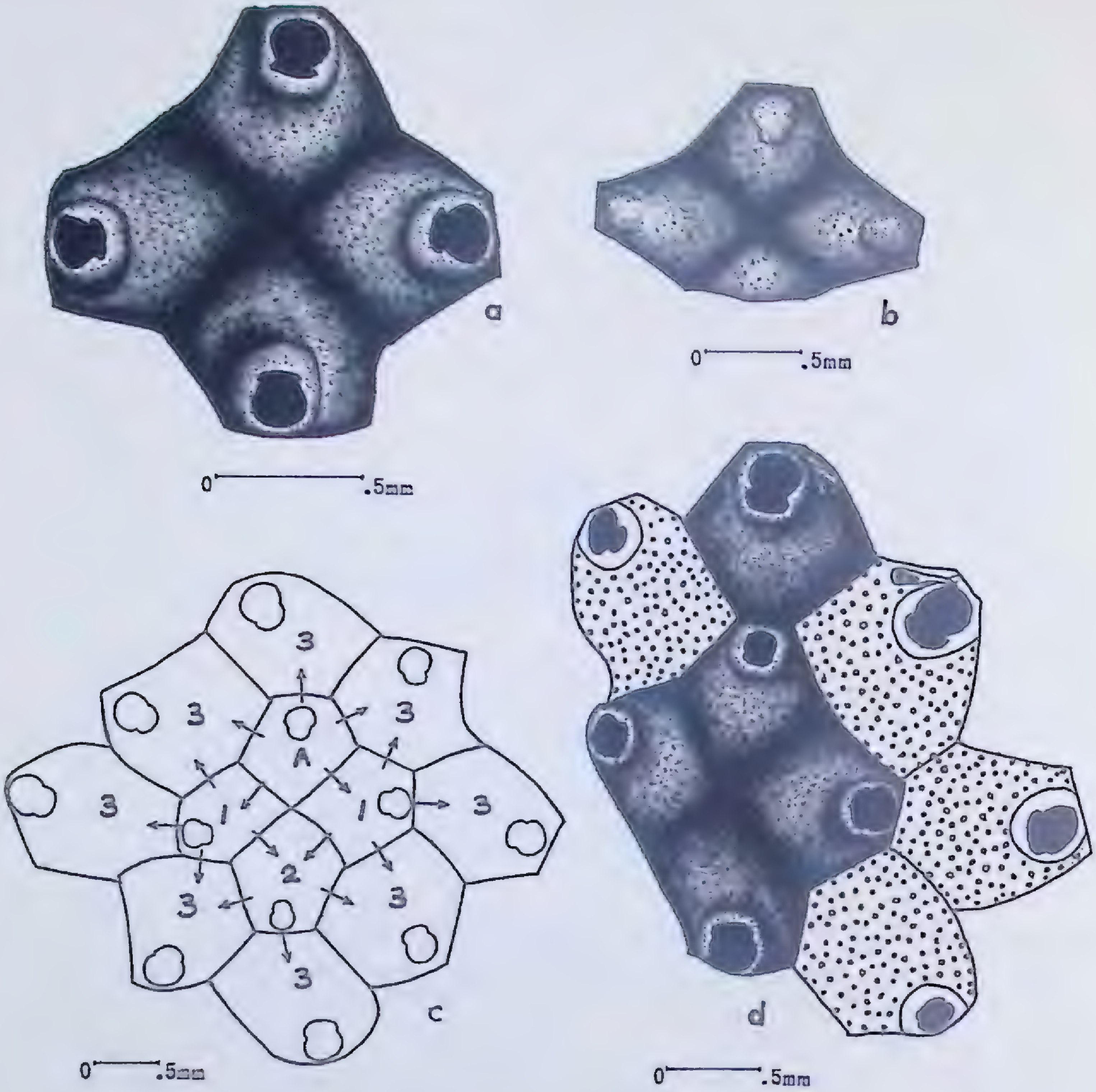
The early astogeny of *Hippopodina feegeensis* is described and shown to differ from the usual cheilostome budding pattern by generating two first-generation zooecia proximally from the distal ancestrula, the former producing a fourth proximal member, thereby completing a distinctive tetrad structure. Owing to the close morphological similarity between members of this growth stage, it was not possible to distinguish the ancestrula until still earlier stages were examined.

INTRODUCTION

In the majority of known multiserial encrusting cheilostomatous Polyzoa, development of the zoarium is initiated by the budding of the ancestrula into two or more zooecia distally. The ancestrula is eventually surrounded by successive generations of periancestrular zooecia, developing from primary buds in a proximal direction.

Abundant fertile material of *Hippopodina feegeensis* (Busk), collected from the sub-littoral zone of Massawa Harbour, South Red Sea, in April 1965, showed considerable deviation from the usual budding pattern. Fixed on cement blocks and wooden debris were several very young colonies, each comprising a characteristically stellate structure of four individuals attached to each other at their proximal extremities (Plate I, text-fig. a). It was impossible to decide solely from this growth stage which zooecium was the ancestrula, as all four individuals were morphologically similar, having approximately equal dimensions. They would seem to have undergone simultaneous development as the zooecia budded from the primary tetrad are considerably larger and often irregular in shape (Plate I, text-fig. d). It was not until the earliest stage represented (Plate I, text-fig. b) was examined that it became evident that astogeny in the Red Sea material does, in fact, proceed by successive budding from a primary zooecium, but in a proximal direction. In this specimen, the distal zooecium was fully calcified, the two lateral members incompletely so, while the development of the proximal member had only just begun. The lateral zooecia are therefore to be interpreted as first-generation derivatives from the distal ancestrula, the former both contributing to the development of the fourth, or second-generation, member proximally. Peripheral budding is inhibited until this fourth member of the tetrad is fully formed, and it is then established distolaterally by the ancestrula; all three remaining individuals contribute buds until a third generation of eight zooecia (Plate

PLATE I



Figs.

- a Tetrad of zooecia, comprising the distal ancestrula, two lateral second-generation zooecia and a third-generation zooecium proximally.
- b Triad of zooecia; the distal ancestrula is fully calcified, the two lateral members almost so. Development of the proximal zooecium has just started.
- c Showing the arrangement of third-generation zooecia around the tetrad. The arrows indicate the origins of the zooecia. A, ancestrula; 1, 2, 3, first-, second-, and third-generation zooecia respectively.
- d To show the partial development of third-generation zooecia around the tetrad, two of the former with avicularia. Note the increased dimensions of the younger generation zooecia compared to those of the tetrad.

Camera lucida drawings of material collected from the sub-littoral zone of Massawa Harbour, Ethiopia (Nat. Mus. Canada Cat. No. 22).

I, text-fig. c) encloses the tetrad (the number is not constant). It is important to point out that although this budding mechanism is the reversal of the usual process the same disposition of third-generation zooecia is achieved (cf., *Australiana bifenestrata,* Powell, 1966, text-fig. 1i).

Waters' (1909: pl. 17, fig. 21) figure of a very young colony of *Lepralia* sp. comprising three zooecia from Ras el Millan, Red Sea, is of special interest. I quote from Waters (p. 172): "The figure shows the primary zooecia of a *Lepralia* which cannot at present be determined, *though,* as the three primary zooecia occurring together in this way is unusual, it will probably be identified on some future occasion." This distinctive triad of zooecia, without a central ancestrula, and the closely similar orifice, as well as the evenly perforated frontal wall, is good evidence for assuming Waters' specimen to be *H. feegeensis* in which the fourth member had not yet developed (cf. text-fig. b). Waters' conclusion that all three zooecia were of primary origin is no longer tenable in the light of the foregoing observations.

Harmer (1957, p. 976) examined a young colony from Torres Strait and remarked: "The ancestrula is surrounded by a cycle of five zooecia . . . ." No specimen in the British Museum (Natural History) shows such development. All colonies instead exhibit the proximal budding as described above, including those listed:

H. feegeensis (Busk)

Locality: Clairmont I. Northeast Australia,
11 fathoms. 1882.2.23.551b "Alert" Coll.

Locality: Siboga Stat. 99, Group B.62.
North Ubian, Sulu Archipelago, 8–12 fathoms.

Locality Massawa, South Red Sea, sub-littoral, 1965.2.4.1.

Similarities between this form of budding and that in *Cupuladria canariensis* (Busk) as described by Lagaaij (1963, text-fig. 10) are apparent.

The implication of the present study however is clear—the classical assumption of "three zooecia growing distally from the ancestrula" in the encrusting Cheilostomata (Waters 1925: 342) is not always valid.

ACKNOWLEDGMENTS

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I am very grateful to Miss P. L. Cook, British Museum (Natural History) both for her assistance in collecting the material and for criticizing the manuscript.

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THE LAND SNAIL FAUNA OF FUNDY NATIONAL PARK, NEW BRUNSWICK

By A. H. Clarke, Jr.,[1] J. P. Kelsall,[2]
and G. R. Parker[3]

RÉSUMÉ

En 1964, le Service canadien de la faune a fait une étude sur les escargots terrestres dans le parc national de Fundy, à l'occasion de recherches relatives à une maladie de l'orignal que les escargots auraient pu causer. On a recueilli vingt-quatre espèces de mollusques terrestres que représentaient 1,202 spécimens. Huit de ces espèces étaient inconnues jusqu'ici au Nouveau-Brunswick (*Arion hortensis*, *Philomycus carolinianus flexuolaris*, *Retinella binneyana*, *Striatura ferrea*, *Succinea ovalis*, *Vertigo modesta*, *Vertigo ventricosa* et *Zonitoides nitidus*).

On étudie l'écologie et la zoogéographie de ces espèces et leurs relations avec les types sylvestres. Contrairement aux prévisions, et bien que la pierre calcaire soit à peu près absente de la région, on a trouvé que les forêts de conifères et les forêts mélangées sont relativement riches en mollusques. Il est possible que les facteurs climatiques soient la cause de cette anomalie apparente.

SUMMARY

During 1964 a survey of land snails in Fundy National Park was carried out by the Canadian Wildlife Service in connection with research on a disease in moose in which snails are believed to be implicated. Twenty-four species of terrestrial molluscs were collected, represented by 1,202 specimens. Eight of these species (*Arion hortensis*, *Philomycus carolinianus flexuolaris*, *Retinella binneyana*, *Striatura ferrea*, *Succinea ovalis*, *Vertigo modesta*, *Vertigo ventricosa*, and *Zonitoides nitidus*) were previously unrecorded from New Brunswick.

The ecology and zoogeography of the species are discussed, and their relationships to forest types are examined. Contrary to expectations, and even though limestone is virtually absent from the region, coniferous and mixed forests were found to be relatively rich in molluscs. Possible explanations, based on climatic factors, are suggested for this apparently anomalous situation.

INTRODUCTION

During the summer of 1964 an effort was made to determine the distribution and abundance, by species, of the terrestrial molluscs of Fundy National Park, New Brunswick. The primary purpose of the study was to elucidate factors relative to a 'sickness' that has caused heavy mortality among moose (*Alces alces*) in the Maritime Provinces for over two decades. Some species of molluscs act as the secondary host for a nematode, *Pneumostrongylus* (*Elaphostrongylus*) *tenuis*, that has been shown to be chronic in white-tailed deer (*Odocoileus virginianus*). This nematode can cause motorataxia, paralysis, and death when it attacks the central nervous system of moose (Anderson, 1964; Smith *et. al.*, 1964). In Fundy Park, and in the Maritimes generally, good residual moose populations are now found only in high country where their winter ranges do not overlap those of deer. Since Fundy Park also contains low altitude deer ranges, and since 'moose sickness' due to *Pneumostrongylus* is known to occur there, the area is suitable for a study of the factors involved. It was thought that variations in mollusc distribution or abundance might be important in the survival of moose at high elevations. The study showed, however, that a number of the molluscs that are suitable hosts for larval nematodes are common everywhere.

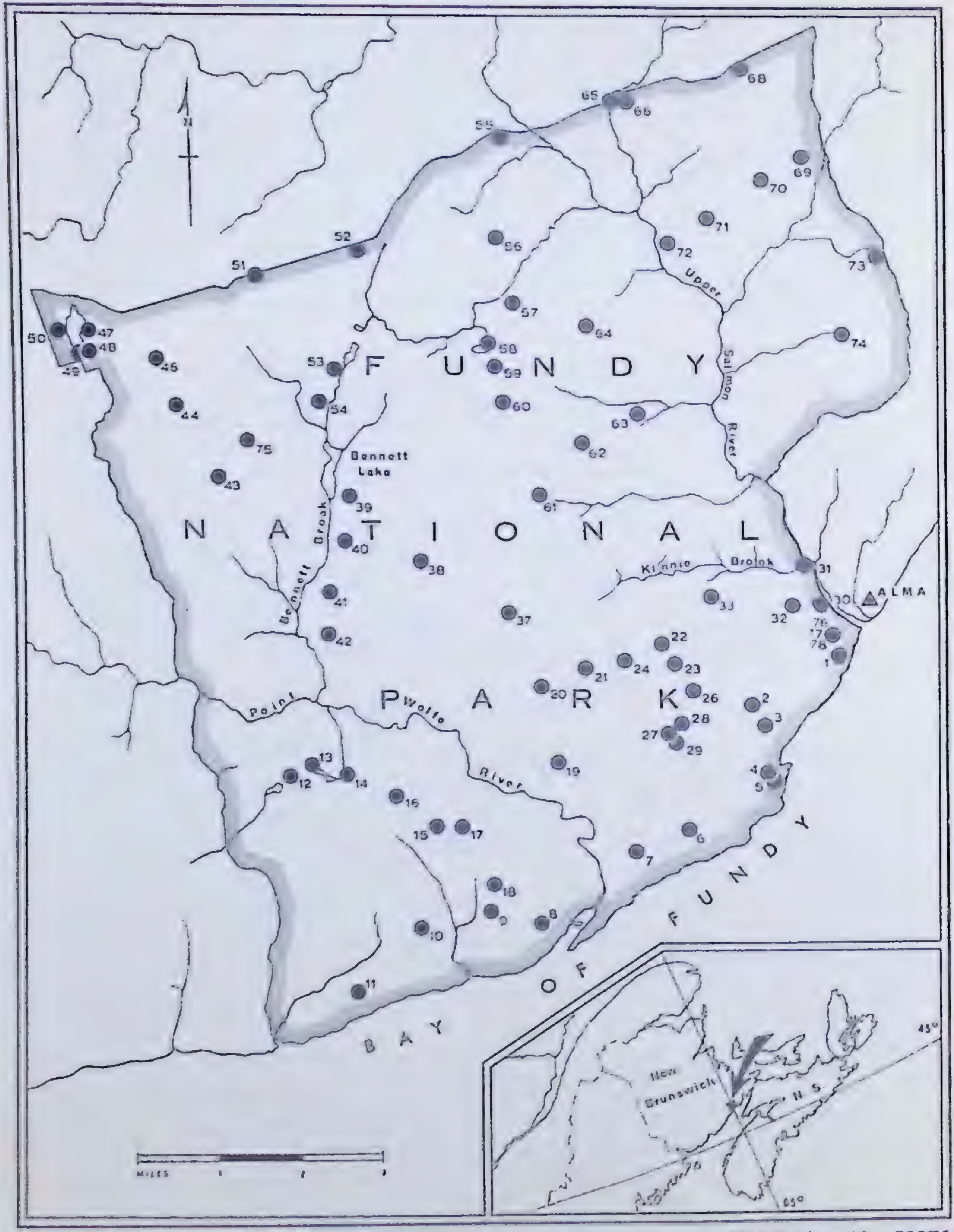
---

[1] National Museum of Canada, Ottawa.

[2] Canadian Wildlife Service, Edmonton, Alta.

[3] Canadian Wildlife Service, Churchill, Man.

The sites searched for terrestrial molluscs and the species collected are listed in the following tables (Tables 1 and 2). It can be seen from the accompanying map (Map 1) that the collecting sites are rather well distributed over the entire park.



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Map 1—*Location of collecting sites in Fundy National Park, New Brunswick.*

Table 1—SITES SEARCHED FOR TERRESTRIAL MOLLUSCS IN FUNDY NATIONAL PARK, N.B.

Site No.	Altitude ft.	Date 1964	Number Species	Number Individuals	Habitat
1	100	June 6	7	13	Woods near Park Hdqrs; white and yellow birch, alders, fir.
2	300	July 9	4	15	Open field under apple tree.
3	550	June 5	5	35	Birch and moose maple mixed with fir.
4	100	May 25	1	19	Alder, few fir trees, muddy.
5	150	May 25	3	11	Side hill; partial clearing; alder, yellow birch, white birch, maple, fir.
6	400	May 25	4	23	Open field with logs and boards.
7	200	July 9	4	20	Open area at dump; heavy grass; under cardboard. Also spruce fir woods.
8	450	July 9	4	14	Fir and spruce mixed; a few white birch. Ground cover lacking.
9	700	July 9	8	28	Fir mixed with red spruce; white birch mixed sparingly. Ferns.
10	800	July 9	5	24	Fairly open slope; mature red spruce with few white birch.
11	700	June 1	9	44	Open area—maple and spruce.
12	850	June 3	9	107	Open area; young maple and few red spruce. Many fallen logs.
14	800	June 25	3	12	Scattered fir and yellow birch; floor covered with ferns.
15	800	June 3	7	13	Birch with few fir.
16	900	June 25	2	2	Mature fir, young fir overbrowsed.
17	800	July 9	6	11	Immature birch and fir. Groundcover—ferns, bunchberries.
18	800	July 9	4	9	Birch, fir, spruce; bunchberries and ferns on ground.
19	1,050	June 19	6	12	Fir stand—mature.
20	1,000	June 19	5	32	Fir, sugar maple, striped maple, beech.

Table 1 (Cont.)

Site No.	Altitude ft.	Date 1964	Number Species	Number Individuals	Habitat
21	1,000	June 19	5	13	Hardwood stand—yellow birch, sugar maple, white birch and ferns.
22	1,100	May 26	4	13	Fir thicket with few birch.
23	1,130	May 27	5	25	Maple and birch.
24	850	May 26	4	23	Swampy area bordering field.
25	850	July 6	4	6	Thick softwood—spruce and fir; also birch; all trees mature.
26	750	May 27	4	22	Maple, birch.
27	550	July 21	1	3	Pure fir stand.
28	500	May 26	4	10	Border of field in fir stand.
29	550	July 21	4	18	Open field beneath mature maple.
30	65	June 8	9	19	Moose maple, yellow birch, white birch, alders, red spruce, and fir; thick.
31	45	June 8	6	37	Young yellow and white birch; red maple; many ferns, fallen logs.
33	950	July 17	3	10	Small fir, mature beech, mature spruce, old yellow birch.
34	900	July 17	0	0	Softwood—red spruce and fir.
35	900	July 17	0	0	Open field.
36	900	July 17	0	0	Softwood—red spruce and fir.
37	1,050	July 11	5	9	Young maple, yellow and white birch, beech, and few fir.
38	1,100	July 10	5	10	Young aspen, birch, and maple, few spruce.
39	1,050	July 10	4	12	Sugar maple, striped maple, yellow and white birch.
40	1,050	July 10	4	12	Young sugar maple, yellow birch, and beech.
41	1,000	July 10	6	16	Open area—red spruce, old yellow birch, wild raspberry.
42	850	July 10	4	14	Fairly open—mature red spruce, odd yellow birch.
43	1,000	July 10	5	21	Fairly open—mature fir, yellow birch, few maple; dense ferns.
44	1,000	June 23	4	25	Beech predominant, few young sugar maple, moose maple, yellow birch.

Table 1 (Cont.)

Site No.	Altitude ft.	Date 1964	Number Species	Number Individuals	Habitat
45	1,100	July 6	7	22	Mainly maple, birch, and beech; scattered spruce and fir; thick.
46	1,150	July 17	7	46	Young maple (sugar), few spruce.
47	1,000	June 10	2	12	Grassy shore of lake, bordered by a few fir and spruce.
50	1,050	June 10	4	14	Beech, yellow birch, fir, young maple.
51	1,050	June 26	2	23	Red spruce—from seedlings to mature timber; young fir.
52	1,050	June 26	3	3	Young red maple and red spruce.
53	1,000	May 29	5	11	Softwood mixed with birch and maple.
55	1,000	June 26	3	12	Red maple (mature), white birch, fir; heavy ground cover of ferns and maple.
56	1,000	June 9	6	21	Young sugar maple, few balsam, fir.
57	950	July 7	5	40	Young maple and beech, very dense and quite damp.
59	1,050	July 7	2	4	Red spruce and birch, fir stunted or dead from overbrowsing.
60	1,100	June 9	4	25	Young sugar maple, red maple, young yellow birch mixed sparingly with beech.
61	1,025	July 11	3	15	Open grassy area. Found under burned logs and boards.
62	1,000	July 11	4	8	Fairly open area consisting of young maple, beech, and spruce.
63	800	July 11	4	13	Red spruce stand on side-hill.
64	1,200	July 7	9	54	Thick stand of beech and young sugar maple, few old birch, very damp.
65	700	July 20	3	10	Swampy and very open, red spruce, white spruce, and fir; found under charred logs.
66	700	July 20	3	10	Open field, high grass.
67	700	July 20	0	0	Softwood—red spruce, fir.

Table 1 (Conc.)

Site No.	Altitude ft.	Date 1964	Number Species	Number Individuals	Habitat
68	1,050	June 26	2	5	Open area having been cut; few red spruce; very dry; no shade.
69	950	June 22	4	22	Red maple, yellow birch, fir.
70	1,050	June 22	5	20	Young beech and sugar maple.
71	950	July 20	3	12	Young maple, few old birch.
72	750	July 20	6	25	Fairly open, bordered by red spruce and maple.
73	1,000	July 20	1	2	Fir, spruce, maple, poor collecting.
74	1,000	July 20	3	24	Stand of fir.
75	1,150	July 17	3	6	Mature yellow birch, young striped maple, sugar maple, red spruce.
76	200	June 5	1	1	Brought in by gardener.
77	200	June 9	2	3	Brought in by gardener.
78	200	June 19	1	1	Brought in by gardener.
79	1,100	July 28	1	2	Red maple, spruce (red), fir.

Table 2—SPECIES COLLECTED IN FUNDY NATIONAL PARK, NEW BRUNSWICK

Species	Specimens Collected	Localities where found
[c] *Anquispira alternata* (Say)	10	5
Arion circumscriptus (Johnston)	43	7
[n] *Arion hortensis* (Férussac)	22	5
Cepaea hortensis (Müller)	5	4
Deroceras laeve (Müller)	29	15
Deroceras reticulatum (Müller)	23	8
[c] *Discus cronkhitei* (Newcomb)	274	48
Euconulus fulvus (Müller)	54	26
Helicodiscus parallelus (Say)	55	18
Mesodon sayanus (Pilsbry)	5	5
Oxyloma decampi gouldi Pilsbry	1	1
Pallifera dorsalis (Binney)	30	13
[n] *Philomycus carolinianus flexuolaris* (Rafinesque)	6	3
[n] *Retinella binneyana* (Morse)	103	27
[c] *Stenotrema fraternum* (Say)	9	5
Striatura exigua (Stimpson)	54	20
[n] *Striatura ferrea* Morse	7	4
[n] *Succinea ovalis* Say	3	3
[n] *Vertigo modesta* (Say)	1	1
[n] *Vertigo ventricosa* (Morse)	2	1
Vitrina limpida Gould	6	1
[c] *Zonitoides arboreus* (Say)	447	55
[n] *Zonitoides nitidus* (Müller)	8	1
Zoögenites harpa (Say)	2	2

[n] Newly recorded for New Brunswick.

[c] Known to carry larvae of *Elaphostrongylus*.

Twenty-four species of terrestrial molluscs, represented by 1,202 specimens, were collected during this survey. Eight species are here recorded for the first time from New Brunswick. This is not surprising, for comparatively few papers have been published on the land snails of the province. Some species, widely recorded from the Maritime Provinces and northern New England, were conspicuously absent. Perhaps the most prominent among these are *Triodopsis albolabris* (Say), *Strobilops labyninthica* (Say), *Cionella lubrica* (Müller), and *Vallonia pulchella* (Müller).

The molluscs reported in this paper were collected by G. R. Parker under the general direction of J. P. Kelsall. The specimens were identified by A. H. Clarke, Jr. Most of the specimens are now in the National Museum of Canada, but some have been deposited with the Canadian Wildlife Service in Sackville, N.B., and with the Department of Biology, Acadia University.

In the following sections, the species collected are discussed with reference to their systematics, ecology, and distribution, and some overall ecological relationships are indicated. In the Systematic Section, numbers of specimens are given in parentheses. Unless otherwise indicated, the species have been recorded previously from New Brunswick (*see* La Rocque, 1961).

SYSTEMATIC SECTION

Family Helicidae

Cepaea hortensis (Müller)

Five specimens were collected at four sites, as follows: 2(1), 76(1), 77(2), and 78(1).

Site 2 is an open field in an area under an apple tree. The other four specimens, which were brought in by a gardener, were taken from the immediate Park Headquarters area. Elevations at these localities vary from 200 to 300 feet. All specimens are of the yellow, unbanded colour phase.

C. hortensis is widely distributed in inland and coastal Europe but in North America is restricted to coastal regions from Newfoundland to Long Island, New York. It has often been thought that the species was recently introduced to North America (e.g., Binney, 1885), but Pilsbry (1939) has cited evidence for much earlier introduction, i.e., Pliocene or Pleistocene. More recently, Clarke and Erskine (1961) and Clarke (1963) have reported radiocarbon ages of 700 ± 225 and 600 ± 45 years B.P. for Indian midden shells associated with subfossil *Cepaea hortensis* in Nova Scotia. The problem has been discussed in an excellent paper by Walden (1963).

Family Polygyridae

Stenotrema fraternum (Say)

Nine specimens of *S. fraternum* were found at five sites, as follows: 11(2), 15(3), 19(1 juv.), 20(2 juv.), 38(1).

All of these localities are forested: one with conifers (19) and the others with both deciduous and coniferous trees mixed. Elevations vary from 700 to 1,100 feet.

Only the northern 'subspecies' *S. fraternum cavum* (Pils. & Van.) has been recorded from New Brunswick (La Rocque, 1961). The specimens collected in Fundy National Park are intermediate in character between *cavum* and *fraternum* s. str. but are closer to the latter. This is in accord with Pilsbry's (1940) opinion that the supposedly distinct northern subspecies *cavum* is of little taxonomic value.

Mesodon sayanus (Pilsbry)

Only five specimens of this species were collected, one at each of the following five sites: 12, 21, 38, 55, and 70.

Each site was in a forested area dominated by, or containing a substantial number of, deciduous trees. The elevations at these localities were all relatively high, i.e., 850 to 1,100 feet. The present records are in agreement with the first part of Pilsbry's (1940) statement that *M. sayanus* lives "among leaves on woodland (deciduous) hillside, also under stone fences and under logs in pastures."

Family ZONITIDAE

Euconulus fulvus (Müller)

Twenty-six sites yielded fifty-four specimens of *Euconulus fulvus*, as follows: 2(1), 8(1), 9(3), 10(5), 11(1), 12(3), 15(1), 17(1), 18(2), 19(1), 20(3), 22(2), 29(1), 33(2), 40(2), 41(2), 42(2), 43(2), 46(2), 53, 54(1), 55(2), 62(1), 63(4), 64(5), 71(3), and 72(1).

All of these sites except one are forested areas, but no ecological preferences for coniferous or deciduous habitats were evident. The exceptional locality is station 2, a site in an open field under an apple tree. Altitudes inhabited range from 300 to 1,200 feet. In the Wolfville, N.S., region, Moore (1963) found this species only in coniferous or mixed forests.

This common species is nearly Holarctic in distribution and in suitable localities occurs from near sea level to altitudes of 8,000 to 10,000 feet (Taylor, 1914).

Retinella binneyana (Morse)

Twenty-seven sites yielded a total of 103 specimens of this minute species, as follows: 1(2), 3(3), 5(1), 9(2), 11(17), 14(3), 15(1), 16(1), 17(2), 20(2), 21(3), 23(7), 24(6), 26(8), 31(2), 40(2), 42(1), 43(5), 44(5), 46(2), 50(1), 51(7), 52(1), 57(2), 60(15), 64(1), 70(1).

All but one of these sites are in forested areas. Of these, nearly half are in deciduous habitats, and the rest are in mixed or coniferous regions. One station (24) is a swampy area bordering a field. Elevations are of all heights varying from 45 to 1,200 feet.

The present records are the first from New Brunswick. Other Maritime records are Grindstone Island, Magdalen Islands (Pilsbry, 1946), and four localities on Cape Breton Island, Nova Scotia (MacMillan, 1955). West and south its range extends to Ontario, Michigan, Ohio, and Pennsylvania. Probably *R. binneyana* is common over much of New Brunswick but has been undetected because of its small size and unspectacular appearance.

Zonitoides arboreus (Say)

Fifty-six sites yielded a total of 446 specimens of this common species, as follows: 1(4), 3(9), 5(6), 7(2), 8(10), 9(8), 10(3), 11(15), 12(44), 14(6), 15(5), 17(3), 18(3), 19(3), 20(15), 21(4), 22(5), 23(9), 24(9), 26(8), 28(2), 29(4), 30(8), 31(23), 37(4), 38(4), 39(7), 40(7), 41(5), 42(10), 43(5), 46(13), 47(2), 50(4), 51(16), 53, 54(2), 55(9), 56(8), 57(20), 59(3), 60(20), 61(4), 62(2), 63(4), 64(15), 65(6), 66(4), 68(4), 69(8), 70(9), 71(8), 72(12), 73(2), 74(15), 75(2), and 4 from an unspecified locality within the Park.

As usual in boreal, eastern North America, *Z. arboreus* was found to be ubiquitous and more abundant than any other terrestrial species. It occurred in all ecological niches sampled and at all altitudes from 45 to 1,200 feet.

Zonitoides nitidus (Müller)

Eight specimens of this species were found, all at a single site (site 9). This is a predominantly coniferous, heavily forested habitat with birch mixed sparingly and with ferns. The elevation is 700 feet.

Z. nitidus occurs only near water or in marshy areas. Although this feature was not specifically noted at site 9, it is safe to assume that the habitat must have been wet.

Striatura exigua (Stimpson)

Nineteen sites yielded fifty-three specimens of this minute species, as listed: 1(3), 8(2), 9(3), 10(5), 12(9), 15(1), 19(1), 23(4), 37(1), 38(1), 39(1), 40(1), 46(6), 50(2), 57(1), 60(1), 64(5), 69(2), 72(4).

All sites are forested, and sixteen of them are in areas characterized by mixed or deciduous trees. Elevations vary from 100 to 1,200 feet.

S. exigua prefers low, wet ground, according to Morse (1867). The present observations show that it also inhabits higher elevations, and a strong affinity for forest localities is evident. This is also indicated by the observations of Moore (1963).

Striatura ferrea Morse

Seven specimens of this rare, minute species were found distributed between four stations, as follows: 8(1), 17(2), 21(3), and 74 (1).

All localities are heavily forested: one contains conifers only, two have mixed vegetation, and one is a hardwood stand. Elevation varies from 450 to 1,000 feet.

Morse's (1864) remark, "found in damp localities," is partly corroborated by the present meagre data. A forest habitat also appears to be necessary, however.

Vitrina limpida Gould

Six specimens of this species occurred at a single locality, site 6. This is an open field with logs and boards and has an elevation of 400 feet.

V. limpida is sporadic and seasonal in its appearance and is probably much more abundant in the Park than these records indicate. It is widespread in southern Canada and northern United States.

Family LIMACIDAE

Deroceras laeve (Müller)

Twenty-nine specimens of *D. laeve* were found at fifteen sites, as follows:

6(6), 10(1), 11(1), 15(1), 19(3), 22(2), 26(1), 28(3), 30(1), 31(1), 46(2), 53, 54(2), 56(2), 64(2), plus one from an unknown site within the Park.

All sites are in forested areas except one (site 6), which is a field with logs and boards. Forest habitats are of all three types—coniferous, mixed, and deciduous—and no apparent preference for either type was exhibited.

D. laeve has a vast range in North America and is known from localities ranging from Baffin Island and Alaska south to Florida and Central America (Pilsbry, 1948).

Deroceras reticulatum (Müller)

Twenty-three specimens of this species were taken from eight sites, as follows: 3(8), 7(2), 11(2), 28(1), 30(1), 31(2), 63(2), 66(5).

Six of the eight sites are in forested areas (coniferous, mixed, or deciduous); one is a refuse dump with long grass and coniferous woods; and one is a field with long grass but without logs or other adventitious cover. Although usually found in fields and gardens (Pilsbry, 1948), the present records show that, in addition, *D. reticulatum* often enters suitable forests. Forest occurrences of this species were also cited by Dimelow (1963).

This is a European species now common and widely distributed in North America through introduction. Strangely, it was not reported from New Brunswick before 1962 when Dimelow recorded it from Sackville, another locality in eastern New Brunswick. *D. reticulatum* is probably common in many parts of the province, however.

Family Endodontidae

Anquispira alternata (Say)

A total of ten specimens of this species were collected from five sites, viz: 9(3), 11(3), 12(1), 41(2), and 72(1).

Four of these localities are open areas containing red spruce and maple or yellow birch. One (site 9) is more heavily forested with fir and red spruce, some birch, and ferns. The ecological relationships seen agree with the observations of Latchford (1885) in Ontario who states that *A. alternata* is the "commonest of our large species, frequenting the open more than others . . . and seems capable of enduring the driest situations."

A. alternata occurs throughout eastern North America from Cape Breton Island (MacMillan, 1955) and New Brunswick (La Rocque, 1961) to western Ontario and south to middle Louisiana, Alabama, and North Carolina (Pilsbry, 1948).

Discus cronkhitei (Newcomb)

Forty-eight of the sixty-seven sites at which land snails were found yielded *Discus cronkhitei* and produced a total of 274 specimens. The station and abundance data are as follows: 2(10), 3(7), 6(2), 7(7), 9(6), 10(10), 11(2), 12(41), 14(3), 15(1), 17(2), 18(3), 19(3), 20(10), 21(2), 22(4), 23(4), 24(3), 26(5), 29(9), 30(1), 31(6), 33(1), 37(2), 38(3), 39(2), 41(5), 42(1), 43(4), 44(3), 46(8), 47(10), 50(7), 53, 54(5), 56(5), 57(16), 59(1), 60(3), 61(10), 62(4), 64(5), 65(3), 66(1), 69(9), 70(8), 72(5), 74(8), 75(2), and 2 from an unknown locality within the Park.

D. cronkhitei occurred everywhere, in all kinds of habitats and at all elevations from which collections were made (45 to 1,200 feet above sea level). It ranks a close second in abundance to *Zonitoides arboreus*. Nearly two-thirds of the sites are in forested areas dominated by, or containing a substantial amount of, hardwood trees. But pure coniferous stands, fields (with and without logs), swamps, and the edges of a lake all yielded specimens also.

No effort has been made to distinguish the nominal subspecies *D.c. cronkhitei* and *D.c. catskillensis* Pilsbry, as has been done by Dimelow (1963). Both morphological types, with intergrades, occur in the Park. It is unlikely that a taxonomic distinction at the subspecies level is valid in the Maritime Provinces.

Helicodiscus parallelus (Say)

H. parallelus (fifty-five specimens) was found at eighteen sites during this survey, as follows: 1(1), 9(2), 11(1), 30(1), 31(3), 37(1), 39(2), 41(1), 44(14), 46(13), 52(1), 56(3), 57(1), 62(1), 64(4), 69(3), 70(1), 72(2).

All sites are forested, and coniferous, mixed, and deciduous areas all produced specimens. The species was also found at all altitudes sampled, i.e., from 45 to 1,200 feet.

H. parallelus is blind and lives on decaying wood in shady or humid places and on damp leaves (Pilsbry, 1948). It has been recorded from an altitude of over 5,000 feet in the Great Smoky Mountains and is distributed from Newfoundland to Alabama, Oklahoma, and South Dakota. It was first recorded from New Brunswick by Bailey (1903).

Family Arionidae

Arion circumscriptus (Johnston)

Forty-three specimens were collected within the Park from seven sites, as follows: 1(1), 4(19), 5(4), 6(9), 24(5), 30(1), and from an unspecified locality (4).

The known habitats are of diverse types, i.e., woods, a partial clearing, a marsh, and an open field. Elevations at these localities are mostly rather low, 65 to 400 feet, but one site (24) has an altitude of 850 feet.

A. circumscriptus is native to Europe but, through introductions, is now widespread in North America. It occurs in scattered colonies from Prince Edward Island and Nova Scotia to Wisconsin and Pennsylvania. It is also in British Columbia and in California (Pilsbry, 1948) and has been recorded previously from New Brunswick (La Rocque, 1961).

Arion hortensis (Férussac)

Twenty-two specimens were collected at five sites: 7(9), 27(3), 28(4), 29(4), and 30(2).

The habitats yielding *A. hortensis* are of several kinds—thick woods (three sites), an open field, and the vicinity of a dump. Elevations are rather low and range from 65 to 550 feet.

Like *A. circumscriptus*, *A. hortensis* has also been introduced to North America and occurs there in diverse ecological situations. It has been recorded in widely scattered localities from Newfoundland to Ontario and Pennsylvania, and also in California and Washington. The present record is the first from New Brunswick.

Family PHILOMYCIDAE

Philomycus carolinianus flexuolaris (Rafinesque)

A total of only six specimens of this species were found at three sites, i.e.: 56(1), 63(3), 75(2).

Each of these sites is forested, one with conifers and two with mixed coniferous and deciduous trees. Elevations vary from 800 to 1,150 feet. Pilsbry (1948) states that this species lives under the bark of partially decaying logs in humid woods. This agrees with our observations.

Although long known from Ontario and most of the eastern United States, *P. c. flexuolaris* was not recorded from the Maritimes until reported from the Chignecto Isthmus of Nova Scotia by Dimelow (1962*b*). The present records are the first from New Brunswick.

Pilsbry (1948) considers *flexuolaris* a northern race (subspecies) and *carolinianus* s. str. a southern race of the same species. Certainly the present specimens correspond with *flexuolaris*. But Pilsbry (1948) has also cited numerous localities for both *flexuolaris* and *carolinianus* s. str. from all over the region from New Jersey to Alabama and Oklahoma. Clearly the taxonomic status of these colour forms needs clarification.

Pallifera dorsalis (Binney)

Thirty specimens of *P. dorsalis* were collected from thirteen sites, as follows: 2(3), 3(8), 16(1), 18(1), 30(1), 37(1), 43(5), 44(3), 52(1), 56(2), 64(2), 68(1), 71(1).

All but one of the positive localities for this species are in forested areas, and no preference for coniferous, mixed, or hardwood trees was detected. The exceptional locality (site 2) is in a field under an apple tree. Elevations vary from 65 to 1,200 feet.

Pilsbry states (1948) that *P. dorsalis* is "found in woods, under bark, in the soil under decaying logs, and sometimes climbs trees." Dimelow (1962*a*) also observed it active in leaf litter. Our observations agree with these.

The only other record of *P. dorsalis* from New Brunswick is that of Dimelow (1963), who found it near Moncton. The species has been recorded from southwestern Maine to Ontario, Michigan, and Virginia. Whether the eastern New Brunswick to Nova Scotia populations are continuous with the main range of the species remains to be worked out.

Family SUCCINEIDAE

Oxyloma decampi gouldi Pilsbry

Only one specimen of this species was found, at site 65. This is a swampy and very open habitat with red and white spruce and fir. Specimens at this locality were collected under charred logs. The elevation is 700 feet.

O. decampi gouldi occurs in marshy places and on and around aquatic vegetation on the muddy edges of ponds, rivers, and ditches. It has been recorded as ranging from the Maritimes (Pilsbry, 1948) to Maryland, Colorado, and Montana. Curiously, however, the present record is the first for New Brunswick.

Succinea ovalis Say

Three specimens of *S. ovalis* were found, one at each of three sites, viz.: 1(1), 61(1), and 77(1).

Habitats represented are a hardwood forest; under logs and boards in an open, grassy area; and an unknown locality within the Park. Elevations vary from 100 to 1,025 feet.

Pilsbry (1948) states that its usual habitat is on low ground near streams but that it also occurs on tree trunks and in dry woods under stones and leaves. It ranges from Newfoundland and James Bay to North Carolina, Missouri, and Minnesota.

Family PUPILLIDAE

Vertigo modesta (Say)

Only one specimen of *V. modesta* was found. The habitat is a damp, hardwood forest at 1,200 feet elevation (site 64).

Although wide-ranging in Canada (Labrador to British Columbia), Alaska, and New England, *V. modesta* has not been previously recorded from New Brunswick.

Vertigo ventricosa (Morse)

Only two specimens of this small pupillid were found, both at site 12. This is an open, forested area with young maple, a few red spruce, and many fallen logs. Its elevation is 850 feet.

V. ventricosa has been recorded from the Magdalen Islands, Prince Edward Island, Quebec, and much of the northeastern United States, but not from New Brunswick. The present record is the first for that province.

Family VALLONIIDAE

Zoögenites harpa (Say)

Two specimens of this interesting species occurred, one at each of two sites, i.e.: 1(1) and 53, 54(1).

One site is a hardwood forest at an elevation of 100 feet, and the other is a mixed coniferous-deciduous stand at 1,000 feet.

Z. harpa has an immense range and occurs in boreal and mountainous regions of North America, Europe, and Asia. It is typically a forest species and has been recorded frequently from eastern Canada and from Maine.

DISCUSSION

Although some recent studies have dealt with the ecology of a few of the eastern land snails, especially slugs (e.g., Getz, 1959; Karlin and Naegele, 1960; Ord and Watts, 1949), for most of the species there is surprisingly little published information. Even H. A. Pilsbry's magnificent monograph of the land snails of North America includes only a brief comment on the ecology of most species. The best general reference on the subject is still W. G. Binney's *A Manual of American Land Shells* (1885), although, of course, the nomenclature is almost entirely out of date.

Perhaps the most interesting facet of the current study is the observed relationship of the various species to coniferous, mixed, and deciduous forest habitats, and to fields.

Generations of North American malacologists have accepted as fact the premise that coniferous forests are poor habitats for terrestrial molluscs. The generalization appears to have originated with Wetherby (1880), who stated that in mixed coniferous-deciduous habitats near Beaumont, Texas, and in Tennessee, Kentucky, and North Carolina, although land snails were abundant under wood in general they were always absent under pine logs. Sterki (1892) disputed this contention, but Pilsbry (1892) and Walker (1902) supported and extended the concept. Their view, in the words of Walker (1902, p. 1955), was that "Coniferous forests are usually quite barren of molluscan life."

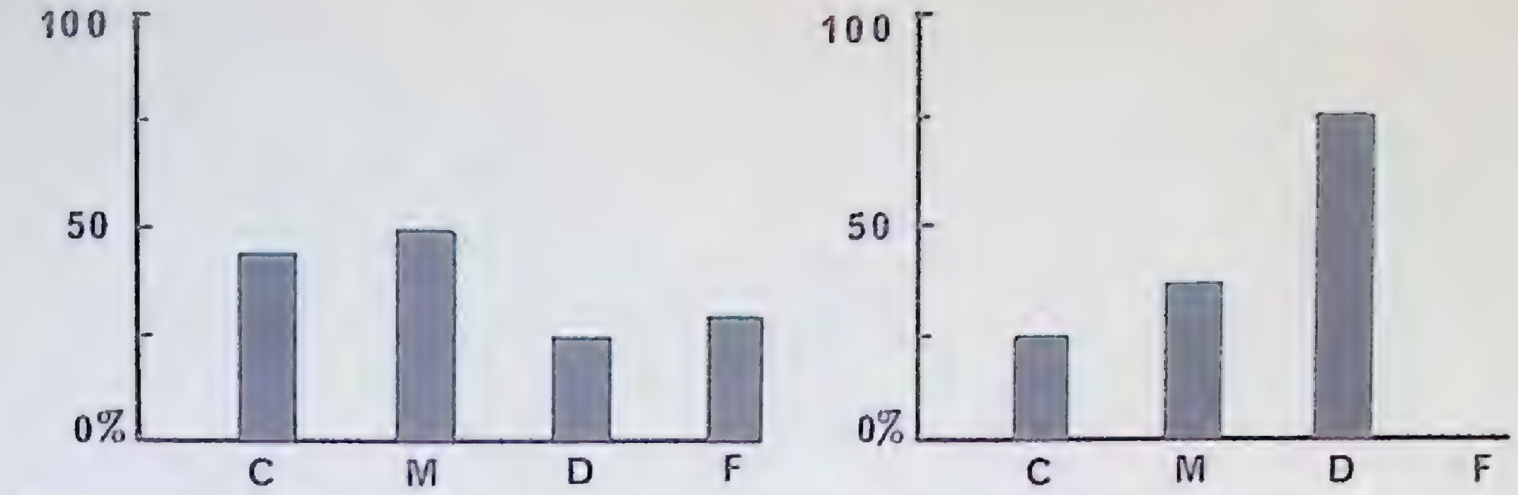
Recently, van der Schalie (1940) has summarized the literature relating to the affinity of land snails for hardwood forests and their supposed absence from coniferous forests. On page 369 he states: "In conclusion, we believe that the contentions of earlier workers, that coniferous forests in eastern United States are usually barren of molluscan life, are in general valid." He has shown that land snails are moderately common (nine species found) in northern Michigan coniferous forests, which grow in some limestone regions, however.

There is little published information that can be used to test the accuracy of this view, although some limited data are available. Clapp (1900) reported twenty-three species of land snails from near Kennebunkport, Maine, but listed only two species (*Zonitoides arboreus* and *Discus cronkhitei*) as common in pine and spruce forests. Colton (1903) cited twenty-two species from the vicinity of Mt. Desert Island, Maine, but from the single coniferous locality mentioned he recorded only one species, *Zonitoides arboreus*. Alexander (1947) reported a somewhat richer but still rather meagre snail fauna (seven species) from cedar grove habitats at Cape May, New Jersey.

The senior author can state from personal experience that in some parts of New England careful searching in coniferous forest habitats has yielded only four or five species (*Z. arboreus*, *D. cronkhitei*, and various species of slugs), and often even less. He is not willing to assert that this is a general phenomenon, however, because, since coniferous forests were believed to be poor collecting areas, not many such habitats were thoroughly sampled.

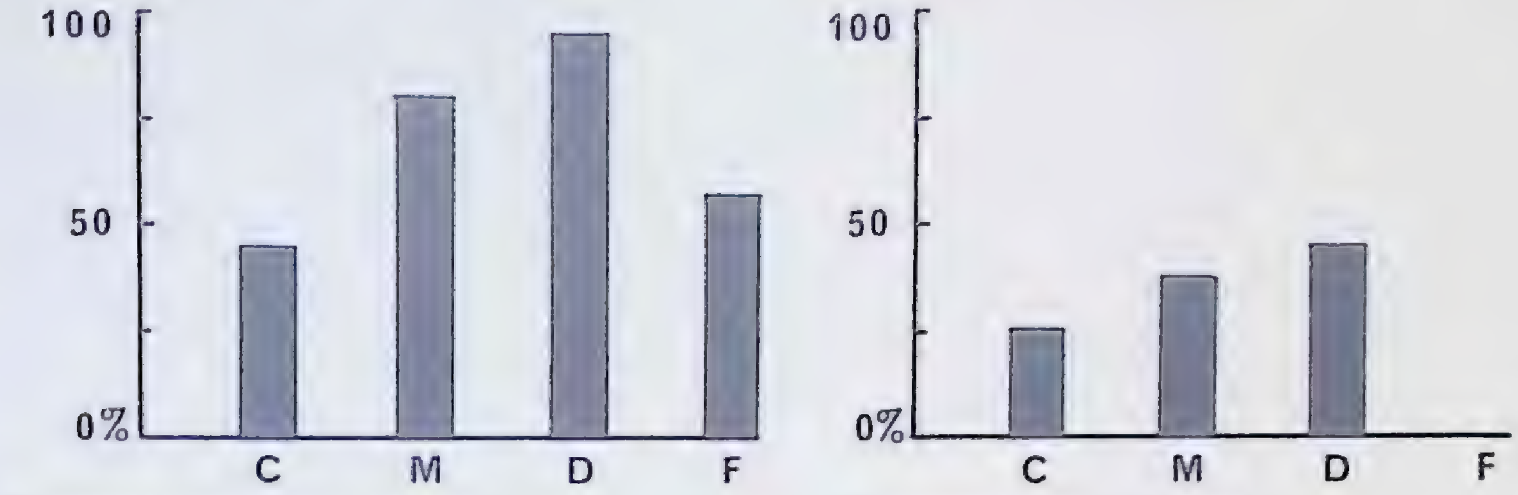
During the present survey, eight of the land snail species encountered were found at thirteen or more stations and are considered sufficiently abundant to permit an attempt at analysing their habitat preferences. These approximations are shown in the accompanying histograms (Figure 1). It can be seen that one species, *Deroceras laeve*, was found slightly more frequently in coniferous forests than in any other habitat. Two species, *Euconulus fulvus* and *Pallifera dorsalis*, were found in a higher proportion of the sampled mixed forest habitats than elsewhere. The other five species all occurred more often in hardwood forest habitats. However, each of the eight species also occurred in significant numbers in coniferous and mixed habitats.

Of all twenty-four species collected, sixteen were found in at least one coniferous forest habitat, eighteen in at least one mixed forest habitat, fourteen in at least one hardwood forest habitat, and eleven in at least one open field habitat. These data indicate that, at least in Fundy National Park, coniferous forests are not the most favoured habitats for land snails but that they nevertheless do support most species found in the region, and in considerable numbers. Such forests are far from barren of molluscan life.



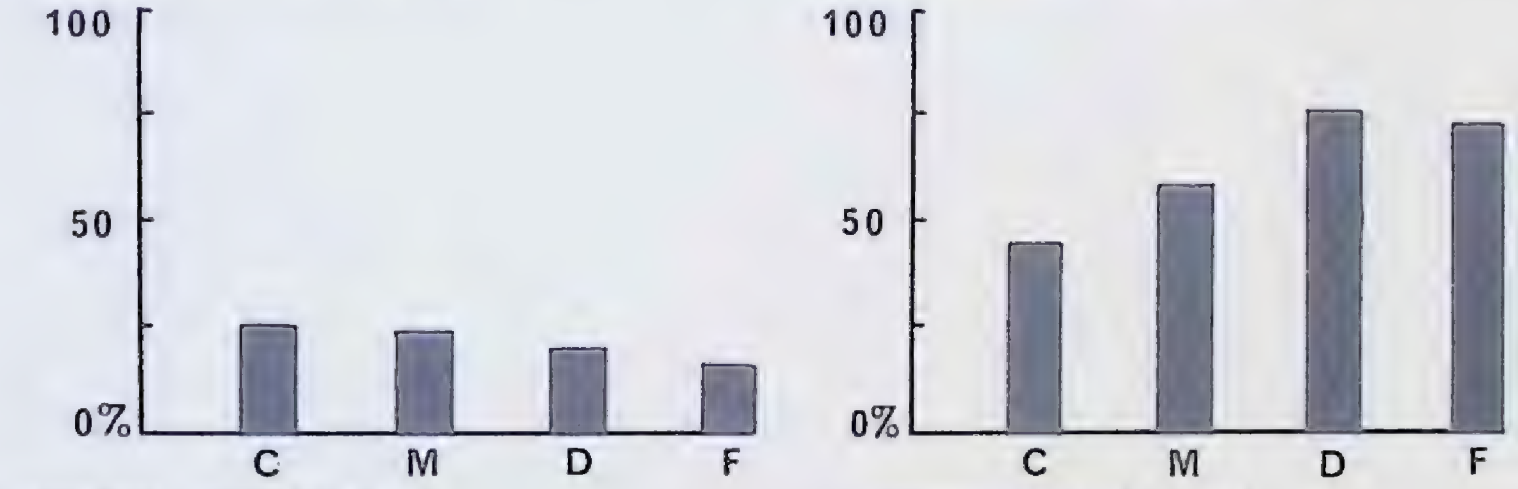
Euconulus fulvus (26 sta.)

Retinella binneyana (27 sta.)



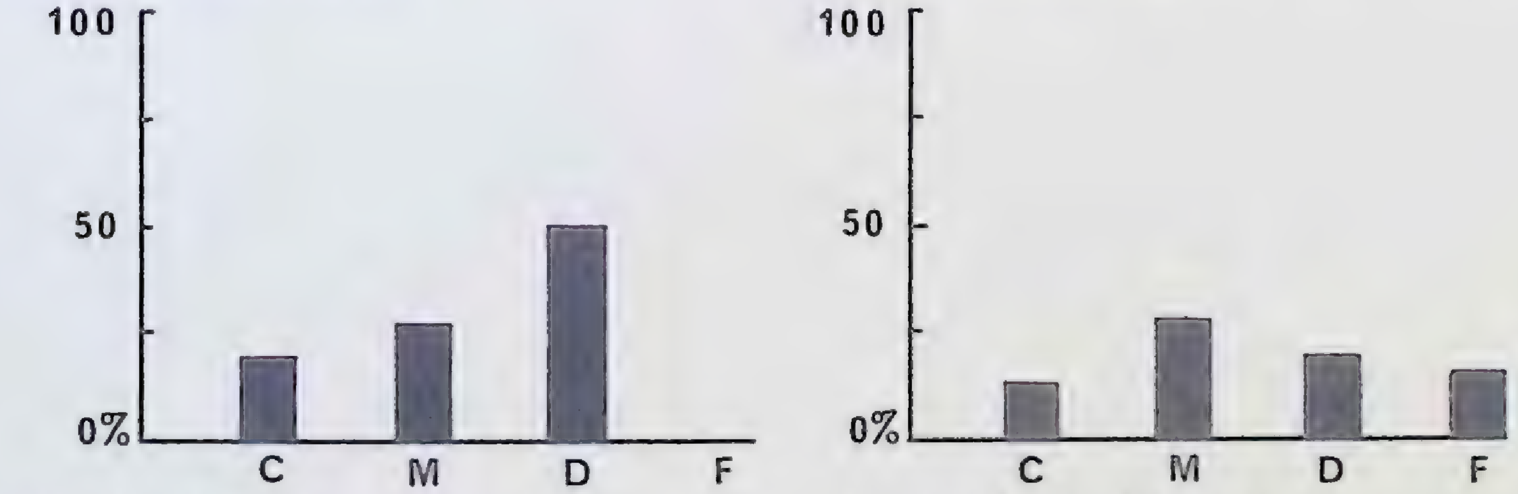
Zonitoides arboreus (56 sta.)

Striatura exigua (19 sta.)



Deroceras laeve (15 sta.)

Discus cronkhitei (48 sta.)



Helicodiscus parallelus (18 sta.)

Pallifera dorsalis (13 sta.)

NMC Neg. No. J18716-1

FIGURE 1—*Frequency data for each of the eight most abundant species of terrestrial molluscs.* Percentages of sites occupied, by habitat, are indicated. (For example, *E. fulvus* was found at 44 per cent of the coniferous sites visited, etc.) Abbreviations are: C, coniferous forests; M, mixed coniferous-deciduous forests; D, deciduous forests; F, fields; sta., stations (= sites). *See* text.

The most recent geological map of the Fundy National Park region (Geological Survey of Canada, 1961) shows the Park to be underlain by Palaeozoic and some Mesozoic rocks nearly devoid of calcareous material. A narrow band of sandstone conglomerate exists near the Fundy shore, and this, in addition to the few scattered shale deposits, may have provided some small amounts of calcareous material to isolated patches of soil close to the shoreline (*see* Aalund and Wicklund, 1950). In general, however, the Park area lacks limestone and other calcareous deposits to the extent that is often seen in parts of New England and the Mid-Atlantic States, regions which support coniferous forests apparently quite poor in land snails.

It is difficult to account satisfactorily for the apparently increased faunal richness in coniferous forests of Fundy National Park. One factor, however, which is probably of importance, is available moisture. In general, during the summer months the floors of coniferous forests dry out to a much greater extent than do the broad-leaf-covered floors of mixed and deciduous forests. In Fundy National Park, fog and rain are frequent during the summer (Putnam, 1940), and drying of all forests is minimized. Land snails, which under other conditions might be killed by summer desiccation, could well survive in such a perennially moist habitat.

Clearly the contention that coniferous forests are usually barren of land snails requires further investigation. One is tempted to regard Wetherby's examples as analagous to a situation observed by one of us (A.H.C.) in the Unionidae. In eastern Tennessee, for example, where limestone is abundantly but irregularly distributed, streams flowing over limestone support a rich unionid fauna. Streams in that region which do not come in contact with limestone are, however, often completely barren of unionids, presumably because the local species are physiologically calciphile. In New England, where limestone is scarce, many streams without access to limestone support thriving populations of five or six species of unionids, presumably because local species are not strongly calciphile. Possibly an analogous situation may exist in some populations of land snails, i.e., species living in predominantly alkaline limestone regions might be unable to endure the acidic conditions of coniferous forests whereas those occurring in regions poor in limestone might be less limited.

Whatever the reason may be for the relative richness of the molluscan fauna of Fundy National Park, it is apparent that under some conditions eastern coniferous forests do provide suitable habitats for a substantial number of terrestrial mollusc species.

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THE WATER-MITES OF WESTERN CANADA

By John C. Conroy*

RÉSUMÉ

Il s'agit ici du rapport sur des travaux de recherches faits sur place au sujet de l'hydracarina (hydrachnes) de l'Ouest du Canada. On donne aussi un bref aperçu de ce qui a été écrit sur l'hydracarina canadienne. L'écrit le plus important sur le sujet est celui de Mlle Ruth Marshall (1929). Elle a enregistré 27 genres et 53 espèces. Le présent relevé comporte 32 genres et 140 espèces, dont 14 de l'Amérique du Nord sont inscrits pour la première fois. Cela porte à 37 le nombre de genres au Canada et le nombre d'espèces, à 158. En tout, les 217 stations ont fourni 221 spécimens. La liste complète des stations se trouve à l'appendice I.

SUMMARY

This is a report of field-work and research carried out on the Hydracarina (water-mites) of western Canada. A brief survey of the literature on Canadian Hydracarina is included. The most important paper on the subject is one by Miss Ruth Marshall (1929). She records 27 genera and 53 species. The present survey records 32 genera and 140 species, of which 14 are recorded from North America for the first time. This raises the number of genera recorded from Canada to 37 and the number of species to 158. In all, 221 collections were made from 217 stations. A complete list of stations is included as Appendix I.

INTRODUCTION

This paper deals with a preliminary survey carried out in the summers of 1964 and 1965 to further the study of the hydracarine fauna of western Canada. The first major survey of Canadian hydracarines Dr. F. Koenike, the German zoologist, carried out in 1895. His report described some thirty species from material Dr. J. B. Tyrrell sent to him from Ontario, Alberta, and British Columbia. Koenike revised his paper in 1912; two of the earlier species were separated, and seven new ones were added. Four papers by Miss Ruth Marshall (1921, 1924 *a*, *b*, *c*,), describing material collected in the Muskegon region and in the Canadian northwest, added nine more species to the Canadian fauna. In 1929, Marshall published a paper on the "Canadian Hydracarina," which represents the major work on this topic up to the present. Much of the material described by Marshall (1929) was obtained in Ontario in connection with the work of the Ontario Fisheries Research Laboratory. In the summer of 1928, D. S. Rawson collected material from Lake Waskesin, Prince Albert Park, North Saskatchewan, during his study of this lake. Several species of water-mites taken in his survey were from the stomachs of fish. Alan Mozley, formerly of the University of Manitoba, Winnipeg, collected hydracarine material from Jasper National Park, Alberta, and from Sturgeon Creek and St. Vital Pond in Winnipeg. His collections yielded only three specimens, which were all described for him by Marshall (1929). Marshall also identified material from Harrison and Cultus lakes, British Columbia, and from the Kootenay region of that province. Of all the hydracarine material available to Marshall, the bulk was thus from Ontario, where it had been collected during fishery operations in lakes Nipigon, Abitibi, and Simcoe during the six years previous to 1928. Other smaller collections were made by Marshall in the Muskegon region near Georgian Bay. In all, 27 genera and 53 species and variables were recorded by Marshall from Canada.

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Little or no taxonomic work has been carried out on the hydracarina of Canada in the period from 1929 to 1964, at which time the present survey was started. During the summer of 1964, the hydracarine fauna of the province of Manitoba was surveyed. Basically this province can be divided into four major biotic zones: Tundra, Taiga, Aspen Parkland, and Prairie. Subdivisions were noticed among these zones, and, so far as feasible, collections were made in each sub-zone, with comparative types of habitats being studied. The net result of the summer's work was that representative collections were obtained of the fauna of each ecological habitat in contrasting areas throughout the province. In 1965, comparative studies were initiated on the biota of southern Saskatchewan, southern Alberta, and southern British Columbia. In Saskatchewan, the Prairie and Aspen Parkland biotic zones were studied, with special stress on the important ecological 'islands' found in the Moose Mountains and in the Cypress Hills. Biotic zones studied in Alberta included the Prairie around the Waterton National Park; the foothills of the Rocky Mountains in the same area; and the Rocky Mountains of Waterton National Park and Banff National Park. In British Columbia, the important semidesert area along the Okanagan Valley, the rainy western hemlock forest area, and the grasslands around Vancouver, all provided interesting and ecologically significant collecting points. The Port Alberni district on Vancouver Island has a wide assortment of lakes and rivers in complete contrast to those on the mainland.

In all, a total of 221 collections were made, of which 124 were from Manitoba, 31 from Saskatchewan, 25 from Alberta, and 41 from British Columbia. A complete list of all stations sampled in the summers of 1964 and 1965 is included as Appendix I.

For purely qualitative samples, a hand-net was drawn through the water and weeds, and the mites caught in it were examined. A burge net was also used for this type of sampling. For quantitative sampling, and this includes the bulk of the samples, collections were made using either a surber sampler or an ekman dredge. The sizes of these pieces of equipment were one foot square and six inches square respectively. The water-mites were preserved in a solution termed Koenike's fluid (five parts Glycerine; three parts water; and two parts Glacial Acetic Acid).

The following groups were also taken: Crustacea (Notostraca, Anostraca, Isopoda, Amphipoda, Decapoda, Ostracoda, Copepoda, Cladocera); insect larvae (Ephemeroptera, Plecoptera, Diptera, Coleoptera, Hemiptera, and Trichoptera); adult insects (Coleoptera and Hemiptera mainly); Annelida (Oligochaeta and Hirudinea); Mollusca (Gastropoda and Pelecypoda); and many other small invertebrates. Labels showing date of capture, station, and other relevant data are included in the specimen tube.

Sincere thanks are extended to the Natural History Branch of the National Museum of Canada, Ottawa, whose financial help made this survey possible; and to the Department of Northern Affairs and Natural Resources, Natural and Historic Resources Branch, who gave permission for collections to be made in the western National Parks.

All specimens taken during the course of this survey will be lodged in the National Museum of Canada.

SPECIES IDENTIFIED

Of the 221 collections taken, 177 have been examined, and the mites in them have been identified. One hundred and forty species, representing 17 families and 32 genera, have been identified. Of the species recorded, 14 are, so far as is known, recorded from North America for the first time. They are *Hydrachna comosa* Koenike, *H. leegi* Koenike, *Hydryphantes dispar* (Schaub), *H. thoni* (Piersig), *Sperchon clupifer* (Piersig), *Torrenticola maglioi* Koenike, *Hygrobates calliger* Piersig, *Unionicola gracilipalpis* (Viets), *Koenikea hamulata* Lundblad, *Piona circularis* (Piersig), *P. litoralis* Viets, *P. variabilis* (Koch), *Forelia cetrata* (Koenike), and *F. ligulifera* (Piersig).

Material from the remaining forty-four stations has still to be examined and identified.

In the species list, the stations where the species were recorded are given. Stations from Manitoba are preceded by the suffix M, stations from Saskatchewan by the suffix S, stations from Alberta by the suffix A, and stations from British Columbia by the suffix BC. The numbers correspond to the station number as listed in Appendix I.

Family HYDRACHNIDAE Leach

Genus *Hydrachna* Muller

Subgenus *Hydrachna* s. str.

1. *H. cruenta* Muller 1776, Zool. Danicae Prodromus, p. 190.
M 32; 60; 70; A 33; 42.

2. *H. magniscutata* Marshall 1927, Trans. Am. Micros. Soc., *46:* 271–272; pl. 7, figs. 8–11.
M 15; 45; 46.

Subgenus *Diplohydrachna* Thor

3. *H. conjecta* Koenike 1895, Rev. Biol. nord France, *7:* 145–146; pl. 18, figs. 9–11.
M 101; 103; S 18; A 33; 42.

Subgenus *Scutohydrachna* Viets

4. *H. crenulata* Marshall 1930, Trans. Wisc. Acad. Sci., *25:* 247; pl. 5m, figs. 6, 7.
M 84.

5. *H. rotunda* Marshall 1930, op.cit., p. 246–247; pl. 5, figs. 4, 5.
M 47.

Subgenus *Tetrahydrachna* Lundblad

6. *H. miliaria* Berleese 1888, Bull. Soc. Ent., Ital., *20:* 219.
M 112.

Subgenus *Rhabdohydrachna* Viets

7. *H. canadensis* Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 63–64; pl. 3, figs. 21, 22, 24.
S 13; 26; A 42; 45; 50.

8. *H. comosa* Koenike 1896, Zool. Anz., *19:* 359.
S 28; A 42; 45.

9. *H. geographica* Muller 1776, Zool. Danicae Prodromus, p. 190 (palaearctic).
M 97; S 10.

10. *H. hesperia* Lundblad 1934, Ark. Zool., *28A* (3): 35–38; fig. 19a–g; fig. 20a–c; pl. 2, figs. 9–11.
A 33.

11. *H. leegi* Koenike 1895, Abh. naturw. Ver. Bremen, *13:* 230; figs. 4–7, 49.
S 18; A 42.

Family LIMNOCHARIDAE Kramer

Genus *Limnochares* Latreille

Subgenus *Limnochares* s. str.

12. *L. aquatica* Linnaeus 1758, Syst. nat., p. 617.
M 22.

Family EYLAIDAE Leach

Genus *Eylais* Latreille

13. *E. abitibiensis* Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 60–62; pl. 1, figs. 1–4.
M 15; 60; 84; 90; 118.

14. *E. extendens* Muller 1776, Zool. Danicae Prodromus, p. 190. Common throughout Manitoba, Saskatchewan, and Alberta.

15. *E. koenikei* Halbert 1903, Ann. Mag. Nat. Hist., *XII*, London.
S 4.

16. *E. rimosa* Piersig 1899, Zool. Anz., *22:* 65–66; fig. 6.
M 68; 102; 107; 108; 112; 114; A 43.

17. *E. robusta* Marshall 1944, Trans. Wisc. Acad. Sci., *36:* 358; pl. 4, figs. 44–46.
M 67; 118.

18. *as no.* 62, Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 62; pl. 1, fig. 9.
M 64; 67; 101.

19. *as Ghost River form A*, Marshall 1929, op.cit., p. 61; pl. 1, fig. 5.
M 67; 118.

Family PROTZIIDAE Viets

Genus *Calonyx* Walter

20. *C. constans* Marshall 1943, Trans. Am. Micros. Soc., *62:* 323; pl. 4, figs. 30–34.
BC 75; 91.

Family Hydryphantidae Thor

Genus *Hydryphantes* Koch

21. *H. dispar* (Schaub 1888), Sitz. Mathem-Natur., Classe der Wiss. Akad., Abt. 1: *XCVII*, Wien,
S 107; A 45.
22. *H. ruber* Geer 1776, Mem. hist. ins., *7:* 141–146; pl. 9, figs. 3–9.
M 101; S 30; A 33.
23. *H. thoni* (Piersig) 1900, Ann. Mus. Petersbg., *4:* 486; pl. 22, fig. 11.
S 4.

Genus *Thyas* Koch

24. *T. stolli* Koenike 1895, Abh. naturw. Ver. Bremen, *13:* 194–196; pl. 2, figs. 29–32.
S 11; 26; 28.

Family Hydromidae Viets

Genus *Hydroma* Koch

25. *H. americanus* Marshall 1926, Univ. Iowa Stud. Nat. Hist., *11:* 33; pl. 1, fig. 4; pl. 2, fig. 8; pl. 3, figs. 13–15.
M 80; S 4; BC 58; 61; 62; 64; 84.
26. *H. despiciens* Muller 1776, Zool. Danicae Prodromus, p. 190.
M 45; 68; 116.

Family Pseudohydryphantidae Viets

Genus *Pseudohydryphantes* Viets

27. *P. orbicularis* Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 67; pl. 4, figs. 36–38.
BC 81A.

Family Sperchonidae Thor

Genus *Sperchonopsis* Piersig

28. *S. verrucosa* Protz 1896, Zool. Anz., *19:* 23–25; figs. 1–3.
M 40; A 36.

Genus *Sperchon* Kramer

29. *S. clupifer* Piersig 1896, Zool. Anz., *19:* 438.
BC 63; 93.
30. *S. glandulosus* Koenike 1886, Zeit. Weissen Zool., *43:* 279–284; pl. 9, figs. 17–24.
M 52; 104; A 54; BC 67; 70; 75; 83; 91; 93.
31. *S. jasperensis* Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 65–66; pl. 2, figs. 14, 15.
BC 82.
32. *S. parmatus* Koenike 1895, Abh. naturw. Ver. Bremen, *13:* 202–204; pl. 2, figs. 40, 41.
M 40; BC 75; 93.

Family LEBERTIIDAE Thor

Genus *Lebertia* Neuman

33. *L. martesensis* Marshall 1943, Trans. Am. Micros. Soc., *62:* 408–410; pl. 3, figs. 23–25.
BC 59; 93.

34. *L. needhami* Marshall 1943, op.cit., p. 408; pl. 13, figs. 28–30.
A 36; BC 67; 69; 75.

35. *L. parmata* Marshall 1912, op.cit., *31:* 226–227; pl. 27, figs. 4, 5; pl. 28, figs. 6, 7.
BC 93.

36. *L. porosa* Thor 1900, Nyt. mag. naturvid., *38:* 273.
M 18; 35; 49; S 31; A 53; BC 72.

37. *L. quinquemaculosa* Marshall 1929, Proc. Indiana Acad. Sci., *38:* 315, 317; figs. 5–8.
M 35; A 36.

38. *L. tyrrelli* Koenike 1912, Trans. Roy. Can. Inst., *9:* 290–293; pl. 1, fig. 16; pl. 2, figs. 13–15.
BC 79; 82; 93.

39. *L. wyomingensis* Marshall 1933, Trans. Am. Micros. Soc., *52:* 39–40; pl. 8, figs. 16, 17.
M 8; 39; BC 88.

Genus *Oxus* Kramer

40. *O. connatus* Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 71–72; pl. 4, fig. 35.
BC 72; 81.

Genus *Frontipoda* Koenike

41. *F. americana* Marshall 1914, Trans. Wisc. Acad. Sci., *17:* 1300–1301; pl. 92, figs. 1–8.
A 35.

Family TORRENTICOLIDAE Oudemans

Genus *Torrenticola* Piersig

42. *T. compactus* Marshall 1943, Trans. Am. Micros. Soc., *62:* 315; pl. 3, figs. 25, 26; pl. 4, fig. 27.
BC 75.

43. *T. ellipsoidalis* Marshall 1943, op.cit., p. 308–310; pl. 2, figs. 11–13.
BC 59; 70; 77; 93.

44. *T. geographicus* Marshall 1943, op.cit., p. 314; pl. 3, figs. 21–24.
BC 75.

45. *T. indistinctus* Marshall 1929, Proc. Indiana Acad. Sci., *38:* 317–319; figs. 16, 18.
BC 63.

46. *T. maglioi* (Koenike) 1907, Abh. naturw. Ver. Bremen, *19:* 233; fig. 19.
M 10.

47. *T. occidentalis* Marshall 1933, Trans. Am. Micros. Soc., *52:* 40; pl. 7, figs. 5–7.
    BC 75.
48. *T. simulans* Marshall 1933, op.cit., p. 40; pl. 7, figs. 8–10.
    BC 70; 92.
49. *T. sierrensis* Marshall 1943, op.cit., *62:* 307; pl. 1, figs. 1–4.
    BC 75; 91; 93.
50. *T. tahoei* Marshall 1943, op.cit., p. 308; pl. 1, figs. 5–7.
    BC 70; 91; 93.

Genus *Testudarcus* Walter

51. *T. minimus* Marshall 1943, Trans. Am. Micros. Soc., *62:* 322; pl. 6, figs. 43–45.
    BC 77.

Family LIMNESIIDAE Thor

Genus *Limnesia* Koch

52. *L. anomala* Koenike 1895, Abh. naturw. Ver. Bremen, *13:* 207–208; pl. 2, figs. 49–53.
    M 35.
53. *L. columbica* Marshall 1924, Trans. Am. Micros. Soc., *43:* 239–240; pl. 11, figs. 9–12.
    M 81; 68; 89; 101; S 15.
54. *L. cornuta* Wolcott 1903, op.cit., *24:* 89–92; pl. 12, figs. 1–5.
    M 41; 45; 47; 63; S 1; 4; 5; BC 58.
55. *L. fulgida* Koch 1835, Deutschl. Crust., Myr., Arach., *2*, no. 19.
    M 21; S 2; 21; A 38; BC 72.
56. *L. maculata* Muller 1776, Zool. Danicae Prodromus, p. 191.
    M 45; 68; S 22; 24; A 35; 41; 53; BC 81.
57. *L. paucispina* Wolcott 1903, Trans. Am. Micros. Soc., *24:* 98–100; pl. 13, figs. 10, 11.
    M 45; S 25; A 34.
58. *L. undulata* Muller 1781, Hydrachnae aus Danicae, p. 80; pl. 11, fig. 1.
    Common throughout all areas surveyed.

Family HYGROBATIDAE Koch

Genus *Hygrobates* Koch

59. *H. calliger* Piersig 1896, Zool. Anz., *19:* 439.
    M 19; 35; 38; A 36.
60. *H. exilis* Koenike 1895, Abh. naturw. Ver. Bremen, *13:* 213–215; pl. 3, figs. 50, 61.
    BC 80.
61. *H. longipalpis* Hermann 1804, Mem. Apterolog., p. 55; pl. 3, fig. 1; pl. 9, fig. P.
    M. 35; 39; 91; BC 58; 69; 70; 74; 75; 82; 92; 93; 94.

62. *H. multiporus* Koenike 1895, Abh. naturw. Ver. Bremen, *13:* 216–217; pl. 3, fig. 64.
BC 82.

63. *H. neooctoporus* Marshall 1926, Univ. Iowa Stud., Nat. Hist., *11:* 34.
M 104; A 53; BC 87.

64. *H. occidentalis* Marshall 1943, Trans. Am. Micros. Soc., *62:* 414; pl. 4, figs. 39–41.
BC 79; 89; 94.

Genus *Attractides* Koch

65. *A. nodipalpis* Thor 1899, Arch. Mathem., Naturw., *21:* (5): 39–40; pl. 17, figs. 120, 121 (palaearctic).
M 39; throughout area sampled in British Columbia.

66. *A. parviscutus* Marshall 1915, Trans. Am. Micros. Soc., *34:* 186; pl. 6, figs. 1–4.
S 31.

Family UNIONICOLIDAE Oudemans

Genus *Unionicola* Haldeman

67. *U. aculeatus* Koenike 1890, Zool. Anz., *13:* 139–140.
M 47; 92.

68. *U. crassipes* Muller 1776, Zool. Danicae Prodromus, p. 189.
M 31; 35; 39; 47; 65; S 1; 24; 25; A 39; BC 61; 67; 81A.

69. *U. gracilipalpis* (Viets) 1908, Zool. Anz., *33:* 50; fig. 1.
M 47; BC 81A.

70. *U. pectinatus* Wolcott 1898, Zool. Bull., *1:* 280; fig. 1.
S 24.

71. *U. ypsilophora* Bonz 1783, K. Deutsche Akat. Naturf. Halle, nova acta Leopoldana, *7:* 52; pl. 1, figs. 1–4.
M 86.

Genus *Neumania* Lebert

72. *N. armata* Marshall 1922, Trans. Wisc. Acad. Sci., *20:* 209; pl. 3, figs. 11–13.
A 39.

73. *N. semicircularis* Marshall 1922, op.cit., p. 207; pl. 2, figs. 2, 3.
S 25; BC 81.

74. *N. tenuipalpis* Marshall 1922, op.cit., p. 207–208; pl. 2, figs. 4–6.
BC 72.

Genus *Koenikea* Wolcott

75. *K. concava* Wolcott 1900, Trans. Am. Micros. Soc., *21:* 190–193; pl. 1, figs. 15, 16, 19; pl. 12, fig. 24.
M 45.

76. *K. haldemani* Viets 1930, Zool. Anz., *92:* 268–272; figs. 6–8.
BC 75.

77. *K. hamulata* Lundblad 1936, op.cit., *95:* (5): 43.
BC 70.

Family Pionidae Thor

Genus *Hydrochoreutes* Koch

78. *H. ungulatus* Koch 1835, Deutschl. Crust., Myr., Arachn., *5*, no. 17.
M 84; A 41.

Genus *Tiphys* Koch

79. *T. diversus* Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 83–84; pl. 5, figs. 48–50.
M 108; A 33.
80. *T. simulans* Marshall 1924, Trans. Am. Micros. Soc., *43:* 244; pl. 14, figs. 46, 47.
M 32; 96; 101; A 34; 35; 37; 39; BC 88.
81. *T. torris* Muller 1776, Zool. Danicae Prodromus, p. 191.
M 38; 96; 101; A 34; 35; 37; 39; BC 88.

Genus *Pionopsis* Piersig

82. *P. latilamellis* Marshall 1924, Trans. Am. Micros. Soc., *43:* 244; pl. 15, figs. 32, 34.
S 4.
83. *P. lutescens* (Hermann) 1804, Mem. Apterolog., p. 57; pl. 6, fig. 7.
A 35.

Genus *Pionacercus* Piersig

84. *P. leuckarti* Piersig 1894, Zool. Anz. *17:* 445 (150).
BC 81A.

Genus *Piona* Koch

85. *P. americana* Marshall 1929, Trans. Wisc. Acad. Sci., *24:* 401–404; pl. 9, figs. 1–9.
BC 72.
86. *P. carnea* Koch 1836, Deutschl. Crust., Myr., Arachn., *8*, no. 24.
M 32; 70; 103; S 27; BC 72.
87. *P. circularis* (Piersig) 1896, Zool. Anz., *19:* 440.
M 75.
88. *P. clavicornis* (Muller) 1776, Zool. Danicae Prodromus, Havniae, p. 189.
S 18; A 34.
89. *P. conglobata* Koch 1836, Deutschl. Crust., Myr., Arachn., *8*, no. 9 (palaearctic).
M 68; 89; S 1; A 38; BC 72.
90. *P. constricta* (Wolcott) 1902. Trans. Am. Micros. Soc., *23:* 222–226; pl. 30, figs. 14–18.
M 103; S 5; A 38; 45.
91. *P. debilis* (Wolcott) 1902, Trans. Am. Micros. Soc., *23:* 234, 250, 252; pl. 32, figs. 44–46.
BC 81A.
92. *P. exilis* (Wolcott) 1902, op.cit., p. 210–213; pl. 29, figs. 3–8.
M 47; 84; S 24; 25.

93. *P. inconstans* (Wolcott) 1902, op.cit., p. 241–243; pl. 32, fig. 47; pl. 33, figs. 48–50.
M 45; 101; A 34; BC 72.

94. *P. insularis* Marshall 1924, op.cit., *43:* 243; pl. 12, fig. 24; pl. 13, figs. 30, 31.
S 26.

95. *P. interrupta* Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 81–82; pl. 6, figs. 59, 60.
M 102; BC 81.

96. *P. litoralis* Viets 1936, Tierwelt Deutschl., *32:* 354–355; fig. 398.
M 30.

97. *P. medius* Wolcott 1902, Trans. Am. Micros. Soc., *23:* 229–231; pl. 31, figs. 30, 31.
A 41; BC 65.

98. *P. nodata* Muller 1776, Zool. Danicae Prodromus, p. 191 (palaearctic).
M 32; 33; 38; 47; 106; 118; all Saskatchewan; A 34; 37; BC 66.

99. *P. obturbans* Piersig 1886, Zool. Anz., *19:* 439–440.
M 39; BC 72.

100. *P. pugilis* (Wolcott) 1902, Trans. Am. Micros. Soc., *23:* 213–216; pl. 29, figs. 9–12.
M 68.

101. *P. reighardi* Wolcott 1902, op.cit., p. 235–239; pl. 32, figs. 35–39.
M 41; 47; 75; A 41; BC 72.

102. *P. rotunda* Kramer 1879, Arch. Naturg., *45:* (Bd 1): 12; pl. 1, fig. 6.
M 31; 32; 41; 45; 46; 47; 75; 101; 115; S 1; BC 60.

103. *P. rubrapes* Marshall 1924, Trans. Am. Micros. Soc., *43:* 241–242; pl. 12, figs. 18–21.
M 32; 108.

104. *P. setiger* Wolcott 1902, op.cit., *23:* 243–246; pl. 33, figs. 51–56.
M 32; 70; S 25; A 34; 45; 48; 47; BC 60.

105. *P. spinulosa* Wolcott 1902, op.cit., p. 226–229; pl. 31, figs. 24–29.
M 47; S 1; 25; A 38; 39; BC 72.

106. *P. variabilis* Koch 1836, Deutschl. Crust., Myr., Arachn., *8*, fig. 382.
S 27; A 32; 33.

107. *P. wolcotti* Marshall 1937, Trans. Wisc. Acad. Sci., *30:* 235–236; pl. 7, figs. 49–52.
M 115.

Genus *Forelia* Haller

108. *F. ligulifera* (Piersig) 1879, Zool. Anz., *20:* 352; figs. 1–3.
M 39.

109. *F. cetrata* (Koenike) 1895, Zool. Anz., *18:* 384; fig. 10.
M 45.

110. *F. lilacea* Muller 1776, Zool. Danicae Prodromus, p. 190.
S 25; A 34.

Family AXONOPSIDAE Viets

Genus *Axonopsis* Piersig

111. *A. setoniensis* Habeeb 1953, Leafl. Acad. Biol., *1:* 9; figs. 23–25.
M 12.

Genus Neoaxonopsis Lundblad

112. *N. pilositarsa* Habeeb 1953, Leafl. Acad. Biol., *1:* 9; figs. 20–23.
BC 70.

113. *N. unguitarsa* Habeeb 1953, op.cit., p. 9; pl. 12, figs. 29, 30.
M 13; 15; A 35; 53.

Genus *Aturus* Kramer

114. *A. mirabilis* Piersig 1897, Sitzungs. naturf. Ges. Leipsiz, *22–23:* 157.
BC 70; 75; 83; 91; 93.

Genus *Kongsbergia*

115. *K. materna* Thor 1899, En. ny. Hydr. stegt., p. 2; pl. 18, figs. 166, 167.
BC 75.

Family MIDEIDAE Viets

Genus *Midea* Bruzelius

116. *M. determina* Marshall 1929, Univ. Toronto Stud., Biol. Ser., *33:* 84–85; pl. 7, figs. 62–66.
BC 66.

Family MIDEOPSIDAE Thor

Genus *Mideopsis* Neuman

117. *M. americanus* Marshall 1940, Trans. Wisc. Acad. Sci., *32:* 140–141; pl. 1, figs. 1–4.
M 11; 65; 84; S 4; BC 64.

118. *M. orbicularis* Muller 1776, Zool. Danicae Prodromus, p. 190.
M 11; 35; 39; 56; 88; BC 91.

Family ARRENURIDAE Thor

Genus *Arrenurus* Duges

Subgenus *Micruracarus* Viets

119. *A. couleensis* Lavers 1945, Trans. Am. Micros. Soc., *64:* 233–234; pl. 1, figs. 1–4.
M 116.

120. *A. scutulatus* Marshall 1908, op.cit., *28:* 93; pl. 8, figs. 17–19.
M 22.

Subgenus *Megaluracarus* Viets

121. *A. aphelocercus* Lavers 1945, Trans. Am. Micros. Soc., *64:* 248; pl. 4, figs. 33–38.
M 35; S 25.

122. *A. belonocercus* Lavers 1945, op.cit., p. 238–239; pl. 1, figs. 7–12.
BC 80.

123. *A. capillatus* Marshall 1908, op.cit., *28:* 101–102; pl. 12, figs. 43–45.
A 44.

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M 46; A 44.

125. *A. kincaidi* Lavers 1945, op.cit., p. 242, 244; pl. 3, figs. 22–26; pl. 6, fig. 63.
BC 71.

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M 39; 73; BC 72.

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M 47.

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A 48.

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BC 71.

Subgenus *Arrenurus* s. str.

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M 55; 116.

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M 65; S 1.

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M 93.

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M 92.

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M 52.

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M 14.

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APPENDIX I . . . *List of Stations*

Summer 1964, Manitoba

The stations sampled are listed according to the vegetation zones of the province.

A) *TUNDRA*

(a) *Churchill area* (nine stations)

1. Marsh on left of road past Royal Canadian Naval base.
2. Marsh by lake on the right side of the road near Akudlik.
3. Marsh by the lake on the left side of the road near Akudlik.
4. Pond near the Airport.
5. Pool near fuel tanks at Airport.
6. Landing on Farnsworth Lake.
7. Pool near Strategic Air Command base.
8. Marsh on the right side of the road before Landing Lake.
9. Marsh on the left side of the road to Landing Lake.

B) *TAIGA*

(i) *Boreal Forest*

(a) *Moose Lake area* (eleven stations)

10–12. Moose Lake (dredges in the Pickerel Channel).
13–15. Trout Island (dredges off east shore).
16. Moose Lake (dredges off Moose Lake Indian Reserve).
17, 18. Point near Bracken Creek; on sheltered and exposed shores.
19, 20. Donit Island (shore collections).

(b) *Flin Flon, The Pas area* (eight stations)

21. Hapnot Lake, Flin Flon.
22. Slough near Flin Flon Pitch and Putt Course.
23. Manistikwan Lake at Kelly's Cabins.
24. Lower Hook Lake.
25. Ditch near the Cuprus Mine.
26. East Channel, Baker's Narrows.
27. Atikameg Lake.
28. Sunset Beach, Atikameg Lake.

(c) *Whiteshell Forest Reserve* (twenty stations)

29. Ditch near Brereton Lake.
30. Slough near Brereton Lake Railway Station.
31. Hanson's Creek at Highway 4.
32. Ditch near the East Gate of the Whiteshell, on the Ontario border.
33. Hunt Lake.
34. Lyon Lake.
35. Falcon Lake, south shore (twice).
36. Starr Lake (at Sue's Folly).
37. Hatchery Creek.
38. West Hawk Lake at Highway 4.
39. Hamilton Creek at Falcon Lake.
40. Hamilton Creek at the Trans-Canada Highway.
41. Barren Lake.
42. Elenore Lake.
43. Dorothy Lake.

44. Nutimik Lake.
45. Green Lake.
46. Slough on the road to the Big Whiteshell Lake.
47. Betula Lake.
48. Whiteshell River at Highway 4.

(ii) *Boreal–Aspen transition*

(a) *Porcupine Forest Reserve* (one station)

49. Bell Lake at the camp-site.

(b) *Duck Mountains* (nine stations)

50. Shell River at Highway 5.
51. Roblin Lake at the picnic ground.
52. Slough near Boggey Creek.
53. Ditch by Wellman Lake.
54. Two-Mile Lake.
55. Marsh by Ketchum Lake.
56. Shell River near Boggey Creek.
57. Laurie Lake.
58. Beautiful Lake.

(c) *Riding Mountain National Park* (twenty-five stations)

59. Lake across the road from Octopus Lake.
60. Hawk Lake.
61. Ditch near Park south gate.
62. Sandy Lake.
63. Clear Lake on Lake Audy road.
64. Jackfish Creek.
65. Lake Audy.
66. Grayling Lake.
67. Edwards Creek.
68. Slough near the junction of Highway 10 and Lake Audy road.
69. Clear Lake near the Golf Course.
70. Shoal Lake.
71. Alfretta Lake.
72. Slough near Shoal Lake townsite.
73. Salt Lake near Salt Lake Beach.
74. Minnedosa River at the dam.
75. Park Lake, Neepawa.
76. Slough near Stoney Creek.
77. Katherine Lake.
78. Whirlpool Lake.
78a. Whirlpool River.
79. Beau Lake.
80. Crawford Lake.
81. Slough on the east shore of Salt Lake.
82. Salt Lake on the east shore.

C) *ASPEN PARKLAND*

(i) *Interlake* (four stations)

83. Washow Creek.
84. Beaver Creek at Lake Winnipeg.
85. Slough near Eriksdale.
86. Lake Manitoba at the Narrows Bridge.

(ii) *West shore of lakes Winnipegosis and Dauphin* (eight stations)

87. Overflowing River.
88. Lake Winnipegosis at One Mile north of 53 degrees.
89. Lake Winnipegosis at Camperville.
90. Lake Winnipegosis at Winnipegosis Beach.
91. Lake Dauphin at Simcoe road.
92. Lake Dauphin at Dauphin Beach.
93. Skunk River at Lake Dauphin.
94. Rainbow Beach on Lake Dauphin.

(iii) *Area around Winnipeg* (eight stations)

95. LaSalle River at LaSalle.
96. LaSalle River at Starbuck Bridge.
97. Slough near Morris.
98. Plum River at Saint Jean Baptiste.
99. Red River at Emerson Bridge.
100. Muckle Creek.
101. Netley Creek.
102. Ditch near Netley Creek.

D) *PRAIRIE*

(i) *Southwest corner of the province* (nineteen stations)

103. Pembina River near Rock Lake.
104. Stream by Avery's Cabins, Rock Lake.
105. Rock Lake near Avery's Cabins.
106. Rock Lake at Rock Lake Beach.
107. Killarney Lake near Lakeside Motel.
108. North end of Pelican Lake.
109. Jackson Creek.
110. Gainsborough Creek.
111. Antler River.
112. Stream entering the Souris River at Melita.
113. Storman Lake.
114. Slough near Adam Lake.
115. Adam Lake.
116. Lake near Bower Lake.
117. Assiniboine River at Virden Airport.
118. Oxbow Lake near Virden Airport.
119. Lake by the road to Oak Lake.
120. Marsh by the Oak Lake camp-site.
121. Oak Lake near the camp-site.

Summer 1965, Saskatchewan, Alberta, and British Columbia

The stations are listed according to the biotic zones in the different provinces.

I. *SASKATCHEWAN*

A) *ASPEN PARKLAND*

(i) *Moose Mountains area* (nine stations)

1. Pipestone Creek at Highway 9.
2. Round Lake on the Qu'Appelle River.

3. Ditch near Broadview.
4. Kenosee Lake.
5. Beaver Dam near the Conservation Officer's house, Moose Mountains.
6. Slough 3.6 miles south of the Conservation Officer's house.
7. Clearwater Lake at Highway 9.
8. Marsh one mile north of Clearwater Lake.
9. Beaver Bay, Kenosee Lake.

B) *PRAIRIE*

(i) *Moose Mountains area* (three stations)

10. Pond on the left of the Carlyle-Manor road.
11. Pond near Railway crossing, Carlyle-Manor road.
12. Slough two miles north of Carlyle.

(ii) *Assiniboia area* (seven stations)

13. Ditch on Highway 2, 4.5 miles south of Assiniboia.
14. Stream by Highway 2 near Scout Lake.
15. Ditch one mile north of the last station.
16. Creek near Willows cut-off, Highway 13.
17. Slough by Highway 2, two miles north of Assiniboia.
18. Slough at the junction of the Congress cut-off and Highway 2.
19. Slough one mile north of the Congress cut-off, on Highway 2.

(iii) *Maple Creek area* (six stations)

20. Slough 100 yards south of the Maple Creek River, on Highway 21.
21. Slough one mile north of last station.
22. Belanger Creek at Highway 21.
23. Slough south of Belanger Creek.
24. Litter Creek at Highway 21.
25. Unnamed stream five miles south of Maple Creek, on Highway 21.

(iv) *Cypress Hills Provincial Park* (six stations)

26. Dam by Loch Leven.
27. Loch Lomond.
28. Longpine Creek at Loch Lomond.
29. Longpine Creek at camp-site.
30. Slough by Highway 221, on left.
31. Slough by Highway 221, on right.

II. *ALBERTA*

(i) *Prairie, Waterton National Park area* (sixteen stations)

32. Slough by the junction of Highways 5 and 6.
33. Slough on right of road by oil pipeline.
34. Slough near Belly River.
35. Galwey Creek at Highway 6.
36. Cottonwood Creek at Highway 6.
37. Slough north of Cottonwood Creek.
38. Paine Lake.
39. Slough by Paine Lake Dam.
40. Ditch by junction of Highway 6 and Paine Lake road.
41. Slough near Marquis Hole.
42. Slough on the left of Highway 5 by oil pipeline.
43. Slough on Belly River Station, Lookout Butte road.

44. Slough one mile south of last station.
45. Lake Maskinonge.
46. Slough by Highway 6, at Waterton Park boundary.
47. Slough by Buffalo Compound, Waterton National Park.

(ii) *Rocky Mountains*

(a) *Waterton National Park* (five stations)

48. Linnet Lake (twice).
49. Upper Waterton Lake.
50. Slough near the Riding Academy, Waterton.
51. Stream on the Akamine Highway, near picnic ground.
52. Stream from Mount Rowe.

(b) *Banff National Park* (five stations)

53. Lake at the junction of Highway 1a and Trans-Canada Highway.
54. Corral Creek at picnic ground.
55. Ditch east of Corral Creek.
56. Marsh by Moraine Lake road.
57. Paradise Creek.

III. *BRITISH COLUMBIA*

A) *OKANAGAN VALLEY* (semi-desert area—eight stations)

58. Okanagan Lake at Peachland.
59. Trepange Creek.
60. Slough near Westbank.
61. Pyramid Point on Lake Okanagan.
62. Soorimpt Point on Lake Okanagan.
63. Trout Creek.
64. Trout Hatchery Bay, Lake Okanagan.
65. Lake Okanagan at Penticton.

B) *RAINY WESTERN HEMLOCK*

(i) *Manning Provincial Park* (two stations)

66. Beaver Pond by Highway 3.
67. River Similkameen, and slough beside it (two collections).

(ii) *Garibaldi Provincial Park* (fifteen stations)

68. Stream near Alouette Lake camp-site.
69. Stream in Alouette Lake camp-site.
70. South Alouette River.
71. North Arm Alouette River, at entrance to Park (twice).
72. Ditch near 'Dinosaur Park,' Haney.
73. Kanaka Creek at Highway 7.
74. Kanaka Creek at 17th Ave.
75. South Arm, Kanaka Creek, at Highway 16.
76. Whonock Lake.
77. Kanaka Creek at Highway 4 (South Arm).
78. North Arm, Kanaka Creek, at 25th St.
79. Alouette River at Hains Road.
80. Ditch at junction of Harris and McNeil streets.
81. McNeil Creek.

81A. Marion Lake.

(iii) *Capilano Canyon* (one station)

82. Lynn Creek.

(iv) *Squamish area* (two stations)

83. Deeks Creek.
84. Browning Lake.

C) *GRASSLANDS*

(i) *Cloverdale area* (six stations)

85. Serpentine River.
86. Nicomekl River west of Cloverdale
87. Nicomekl River south of Cloverdale.
88. Campbell Creek at Meridian Road No. 50.
89. Nicomekl River at 192nd Street.
90. Nicomekl River at 200th Street.

(ii) *Vancouver Island* (five stations)

91. Lockwood Creek at Highway 4.
92. Cameron Lake.
93. Cameron West River.
94. Paper Mill Dam, Port Alberni.
95. Sproat Lake at the camp-site.

FURTHER EXTENSION OF THE KNOWN RANGE OF THE CRAYFISH *ORCONECTES VIRILIS* (HAGEN)

By D. E. Aiken*

RÉSUMÉ

L'*Orconectes virilis* a été décrit comme étant réparti d'une façon sporadique en Amérique du Nord, du Maine à la Californie et, en direction du nord, de la vallée du Mississippi jusqu'en Ontario, au Manitoba et dans la Saskatchewan. Les limites méridionales de son expansion ne sont pas bien établies vu la confusion qui existe en taxonomie entre cette espèce et l'*Orconectes nais*. Les données recueillies sur la répartition du *O. virilis* ne sont pas complètes pour l'Est du Canada mais les études actuelles le font aller jusqu'en Alberta, vu que l'*O. virilis* se rencontre dans la région de la rivière des Castors, dans le centre-est de l'Alberta. C'est là la pénétration la plus à l'ouest au Canada.

SUMMARY

Orconectes virilis has been reported in a discontinuous distribution across North America from Maine to California, and northward from the Mississippi valley to Ontario, Manitoba, and Saskatchewan. The southern limits of the range are not clear because of taxonomic confusion between this species and *Orconectes nais*. Distribution records for *O. virilis* are not complete for eastern Canada, but the present study extends the range to include Alberta, as *O. virilis* is found in the Beaver River system in east-central Alberta. This is currently the most westerly penetration in Canada.

INTRODUCTION

In the summer of 1964 a survey of the principal watersheds of Alberta was undertaken to determine what, if any, crayfish species are present in the province. Rivers arising in Alberta flow north to the Arctic Ocean, northeast to Hudson Bay, and south to the Gulf of Mexico. The Red Deer–Saskatchewan drainage system crosses the provinces of Saskatchewan and Manitoba to enter Lake Winnipeg, and the Milk River runs into Montana, U.S.A., to enter the Missouri River drainage. Since *Orconectes virilis* is known to be present in Saskatchewan and Manitoba and was recently reported from Montana, it was expected that this species would also be present in Alberta.

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GENERAL DISTRIBUTION

Distributional records for *Orconectes virilis* are far from complete, with the greatest confusion involving the southern limits of the range.

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In 1903, Harris reported this species on a north-south line along the Mississippi-Missouri drainage from Texas to Saskatchewan, Manitoba, and Ontario, and ranging east-west from New York to Wyoming.

Faxon (1885*a*) listed eight collections of *O. virilis* in Kansas, and Harris reported twenty-five different collection sites for the state. However, Williams and Leonard (1952) conducted a comprehensive survey of the crayfishes of Kansas and were of the opinion that the crayfish identified previously as *O. virilis* was actually *O. nais*.

Harris also listed several collections of *O. virilis* in Arkansas, Oklahoma, and Missouri. Steele (1902) had previously reported this crayfish as present in Missouri. In 1954, Williams examined the crayfishes in parts of Arkansas,

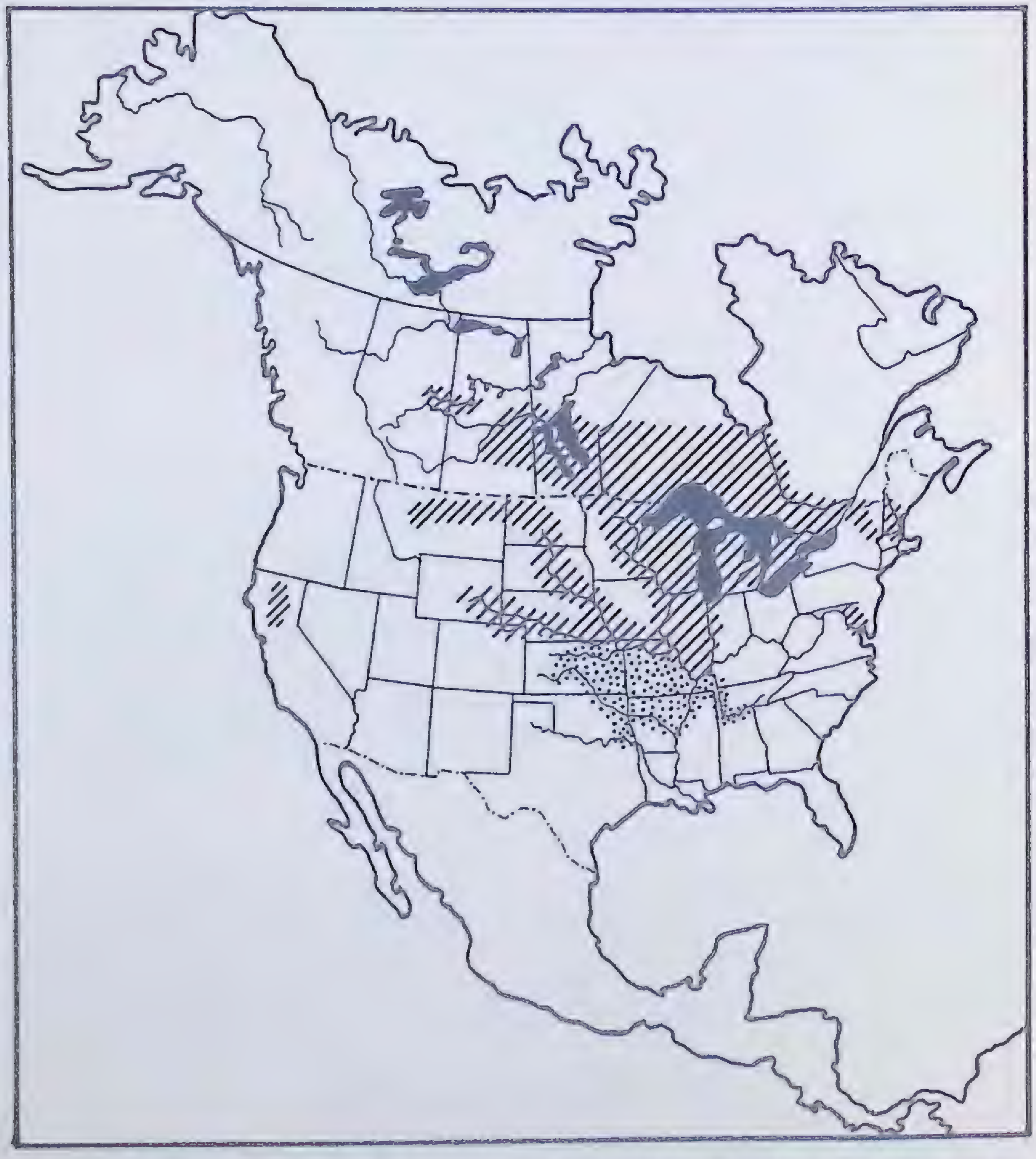

FIGURE 1—Known distribution of *Orconectes virilis* in North America. Crosshatched area represents undisputed range, and stippled area represents the region from which there are conflicting opinions (*see* text for discussion.)

Oklahoma, and Missouri and once again considered the previously reported *O. virilis* to be *O. nais*.

The morphological feature used to separate the two species is the number of rows of punctations at the narrowest point of the areola; *P. nais* has only one row while *O. virilis* has two or more. Width of the areola appears to be quite variable in *O. virilis*. Specimens from Alberta generally have a wider areola than specimens from New England, but in both regions a narrow areola with a single row of punctations is not uncommon.

Hobbs (pers. comm.) also found that areolar width is not constant in large samples of a single population, and he is of the opinion that there are no obvious characters that will permit the separation of the two species. Until a comprehensive study is made of the two species over the entire range it will not be possible to say with certainty that *O. virilis* and *O. nais* are not synonymous. For this reason the map (Figure 1) showing continental distribution of *O. virilis* includes two regions—a crosshatched area that represents the uncontested range of *O. virilis*, and a stippled area representing the region where original records of *O. virilis* have been changed to *O. nais*.

In 1959 Riegel reported the presence of *O. virilis* in northern California, and in 1962 Holthius extended the normal range northwestward to include Montana.

Along the East Coast this species has been reported from New Hampshire (Aiken, 1965), Massachusetts (Travis, 1960), New York (Crocker, 1957), and Maryland (Meredith and Schwartz, 1962). Maryland and California represent isolated populations. Riegel reported that *O. virilis* was introduced artificially at Chico, California, around 1940. Schwartz *et al.* (1963) suggested that the Maryland introduction took place as early as 1885 as a result of escape of the animals from bait fishermen, since this crayfish was commonly shipped to the Baltimore food markets. *O. virilis* is currently rapidly expanding its Maryland holdings at the expense of several other species.

Relatively little work has been done on the crayfishes of Canada. Through the efforts of Faxon (1885*b*), Harris (1903), and Huntsman (1915), the range of *O. virilis* was known to extend along the Great Lakes – Lake Winnipeg – Saskatchewan River system from Saskatchewan to Ontario. Dr. D. W. Crocker and D. W. Barr are currently working on the systematics and zoogeography of Ontario crayfishes, and the range of *O. virilis* given in Figure 1 includes their findings up to 1965. It should be noted that the widespread occurrence of *O. virilis* in Ontario strongly suggests its presence in Quebec as well, but until more information is available from this area the precise Canadian distribution will not be known.

In 1944, Rawson and Moore studied the limnology of sixty freshwater and saline lakes in central Saskatchewan and reported that *O. virilis* was common in several lakes in the east-central region of the province and that it was also found in such widely separated spots as Cold Lake (Churchill drainage), Beaver (Amisk) Lake near Flin Flon (Saskatchewan drainage), and Last Mountain Lake (Qu'Appelle River drainage). In 1965, J. Kilgour of Leduc, Alberta, collected *O. virilis* from Little Bear Lake. This lake, 75 air miles from Beaver Lake, is connected to it by a long chain of lakes and rivers. If *O. virilis* reached Little Bear Lake by normal dispersal, this might indicate rather extensive distribution in the region.

ALBERTA DISTRIBUTION

Because of the presence of *Orconectes virilis* in the upper Missouri drainage in Montana and in the Saskatchewan River drainage in Saskatchewan, it was assumed that this species would be found in Alberta in the watersheds of both the Milk and Saskatchewan rivers. Such was not the case. No crayfish were collected from any part of either the Milk or Saskatchewan rivers; they were found to be abundant only in the Beaver-Amisk drainage. The Amisk arises in the east-central part of the province, joins the Beaver River, flows eastward into Saskatchewan, and then turns north to join the Churchill River, which terminates in Hudson Bay. Thus the Alberta population of *O. virilis* is isolated, and its means of entrance into the Beaver drainage is obscure. Three possibilities exist: (1) the Beaver and Saskatchewan rivers were at one time connected; (2) the proximity of the two watersheds allowed *O. virilis* to transfer from the Saskatchewan to the Beaver, perhaps during periods of high water; or (3) the species was artificially introduced.

Artificial introduction has resulted in isolated pockets of *O. virilis* in Maryland and California, and probably other areas as well. Introduction usually results from use of crayfish as bait, as fish forage, as biological study specimens, or as a commercial and private food source. For many reasons none of these would seem to be a factor here.

The physiography of the area between Prince Albert and Green Lake, Saskatchewan, and the intimacy of the two drainages in that area make either of the first two possibilities more attractive. The watersheds of the Beaver and Saskatchewan rivers approach to within a quarter mile of each other in the region southeast of Delaronde Lake. Here a pond draining east toward Delaronde Lake (Beaver drainage) lies adjacent to another pond at the headwaters of the Sturgeon River (Saskatchewan drainage). The possibility of transfer of crayfish from one drainage to another during periods of high water is worthy of further examination.

In Alberta *O. virilis* is virtually confined to rocky stretches of running

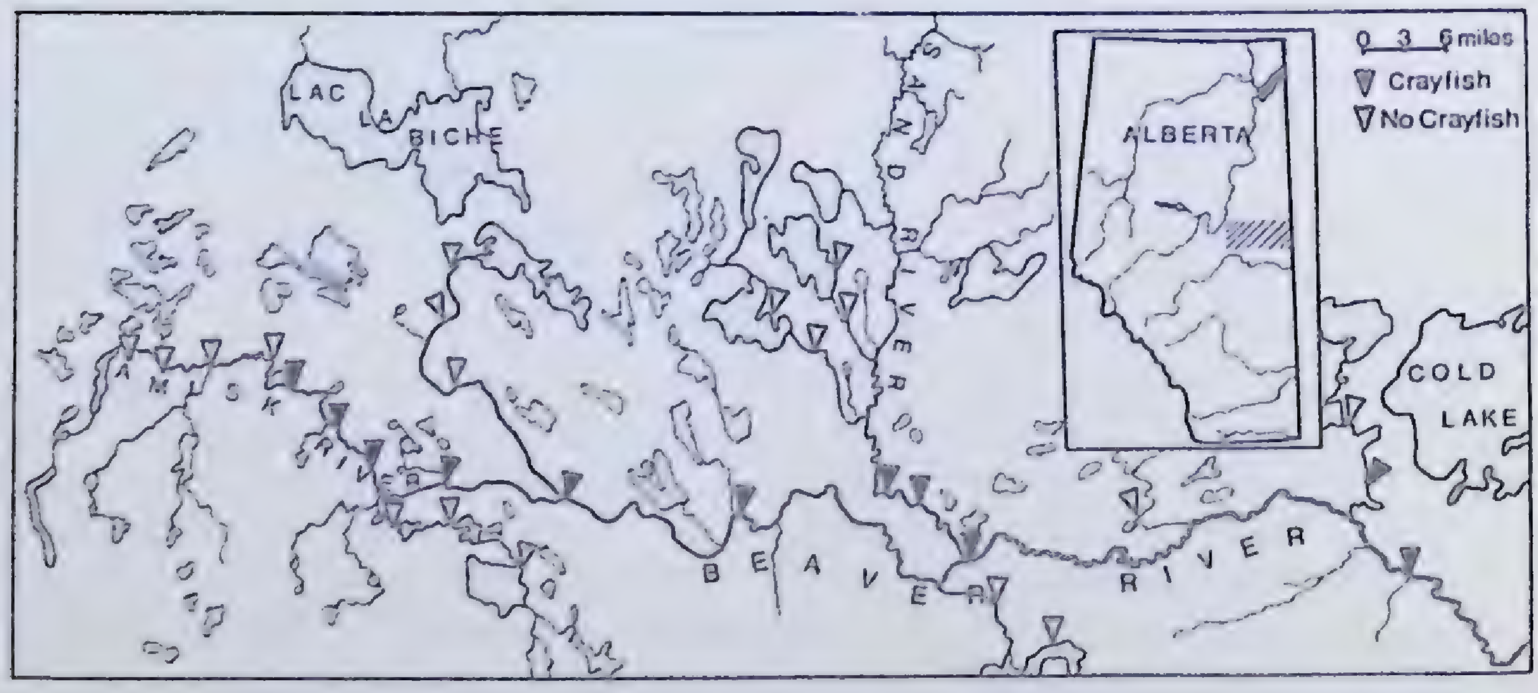

FIGURE 2—Distribution of *Orconectes virilis* in Alberta. Open triangles represent areas where attempts at collection were unsuccessful. Solid triangles indicate successful collection sites.

water. Although it is a frequent inhabitant of lakes and ponds in other areas, no attempts to collect it in or along the shores of lakes and ponds associated with the Beaver drainage have been successful. This species has penetrated upstream in the Beaver River to the point where the Amisk River joins the Beaver. Above this junction *O. virilis* is found principally in the Amisk River, and the total penetration into Alberta is about ninety linear miles.

In the spring of 1964, *O. virilis* was found as far west as Amisk Lake in the Amisk River. Climate and habitat appear to combine to make this the extreme western limit of range for this species in the Beaver – Amisk system. Generally dry conditions in the winter and spring of 1963–64 caused a marked drop in the water level in the Amisk River. By late fall of 1964 the water level was extremely low, and the severe cold of the winter of 1964–65, coupled with very low water, caused a good part of the Amisk River to freeze solidly to the bottom. Especially vulnerable were rocky shoal areas, which happen to be the principal overwintering areas for this species. As a result, the population was virtually wiped out in the Amisk River and severely reduced in the upper thirty miles of the Beaver River. By late summer of 1965 a few adult crayfish had returned to the Amisk River, presumably by upstream dispersal from more populous regions, but there were no juveniles. This situation may be expected to recur from time to time over a period of years and would be an effective barrier to westward dispersal.

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STUDIES ON LITTORAL MARINE INVERTEBRATES OF THE PACIFIC COAST OF CANADA, 1964

I. STATION LIST

By E. L. Bousfield

RÉSUMÉ

L'auteur a visité soixante-cinq endroits au cours d'études effectuées pour le compte du Musée national du Canada sur la répartition et l'écologie des animaux invertébrés intercotidaux, dans la région de la côte centrale de la Colombie-Britannique et sur le littoral sud de l'île Vancouver. Il a indiqué ces endroits sur la carte et mis en tableau les données recueillies aux diverses stations.

SUMMARY

The writer has visited sixty-five places in the course of studies performed for the National Museum of Canada on the distribution and the ecology of intertidal invertebrate animals in the area of the central coast of the province of British Columbia and on the south coast of Vancouver Island. He has marked these places on the map and tabulated the information gathered at various stations.

INTRODUCTION

Investigations on the distribution and ecology of the intertidal and shallow-water invertebrate animals of the northeast Pacific region, conducted by the National Museum of Canada since 1955 (Bousfield 1958, 1963; Bousfield and McAllister 1962), were continued during the summer of 1964 along the central mainland coast of British Columbia and the south coast of Vancouver Island (Figures 1, 2). During the five-week survey, sixty-five collecting stations were established, of which fifty-nine were visited by ship along the 300-mile gross coastline from Queen Charlotte Strait north to Prince Rupert and the remaining six by private automobile along the 100-mile coastline from Victoria westward to Bamfield. Collecting methods were essentially the same as those of the previous expeditions (above). The extensive invertebrate material obtained has since been sorted into major systematic groups and is now available for study. For future reference, and in compliance with modern practice, the station list and maps of station locations are published here.

Success of the field-work along the mainland coast, particularly in the region north of Fitz Hugh Sound, is largely attributable to the chartered assistance of Mr. Spence Huson and crew of the *May S.* from Alert Bay, B.C. Detailed survey work in the region from Rivers Inlet to Goose Islands was made possible through the cooperation of the Fisheries Research Board at Nanaimo. It is a pleasure to acknowledge the competent seamanship and warm hospitality of Captain Hans Getting and crew of the *Investigator I*, and the capable field assistance provided by John Scoggan of Ottawa, Ontario, and Tim Lambert of Saltair, B.C.

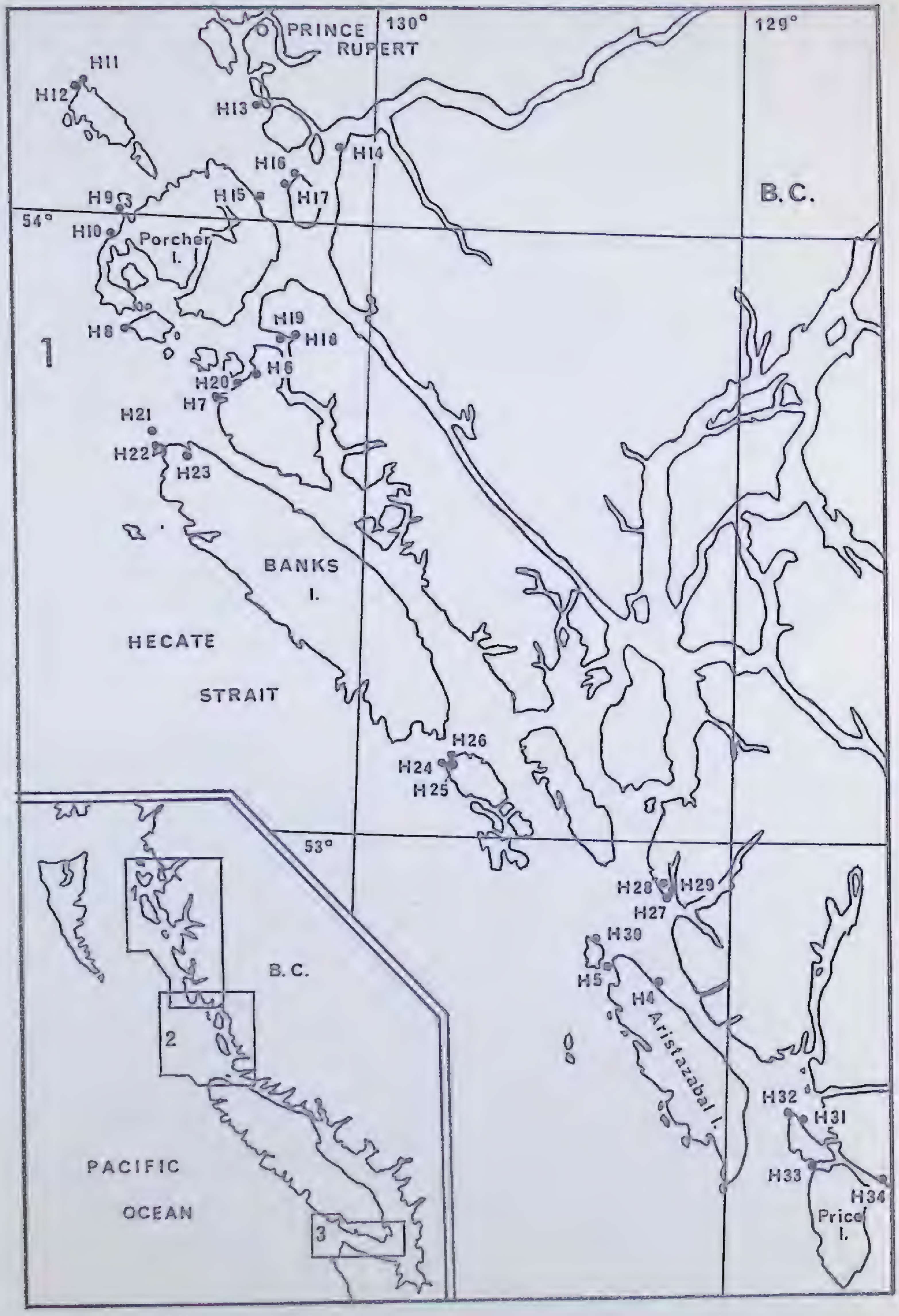

Figure 1—*Localities visited, north-central coast of British Columbia, 1964.* 1. Price Island to Prince Rupert

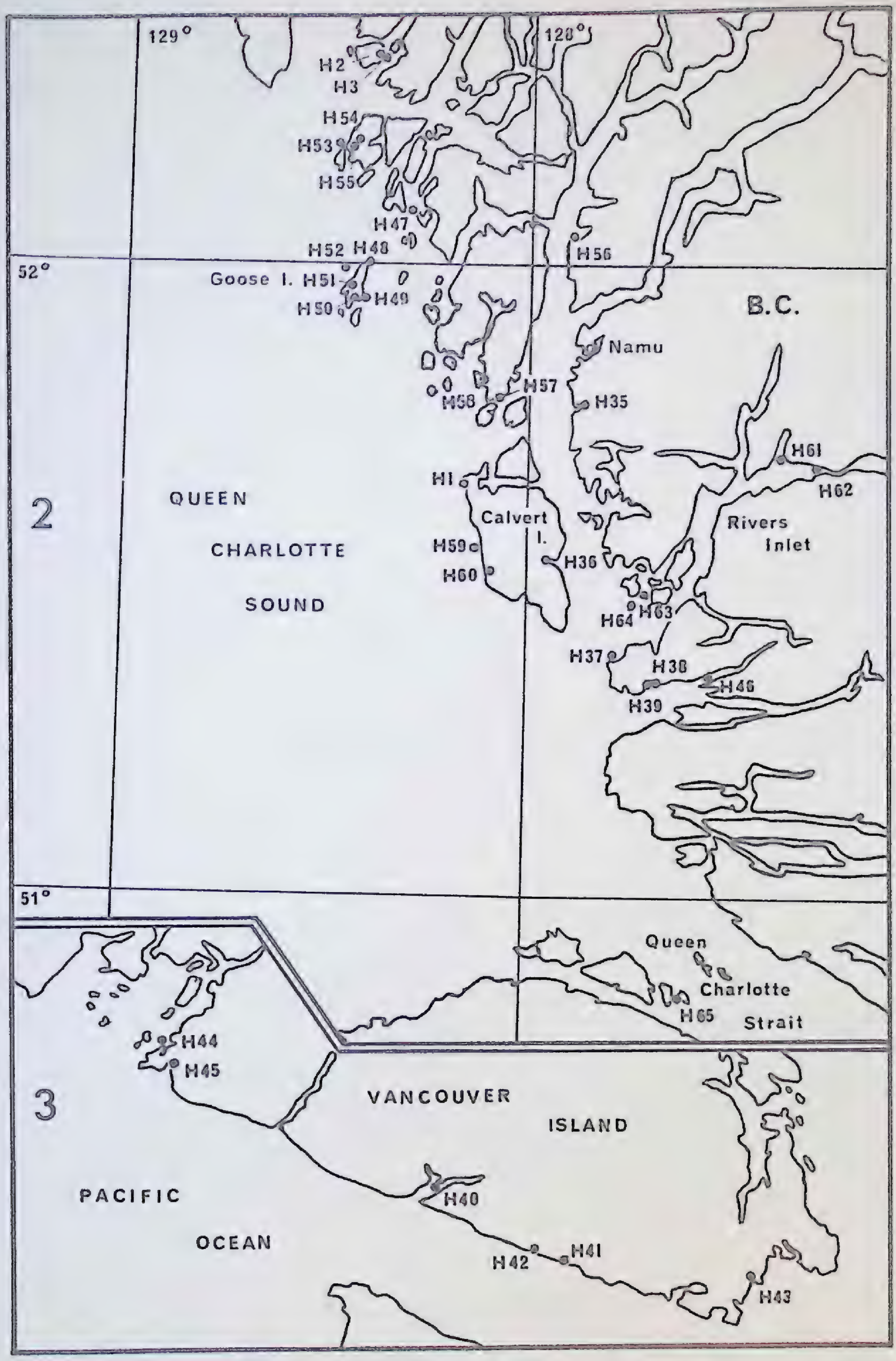

FIGURE 2—*Localities visited, coast of British Columbia, 1964.* 2. Queen Charlotte Strait to Goose I. 3. Southern Vancouver I.

Table 1—LOCALITIES VISITED ON NORTH-CENTRAL COAST OF BRITISH COLUMBIA AND SOUTHERN VANCOUVER I., 1964

Sta. No.	Date	Locality	Lat. and Long.	Habitat	T. ° C.	Sal'y. °/₀₀
H1	July 8	W. Beach, Calbert I.	51° 39′ 128° 09′	Fine sand, boulders, stones, surf beach LW level	12.8	28.0
H2	8	Cockle B., Lady Douglas I.	52° 29′ 128° 27′	Bedrock, MW–HW levels	–	–
H3	9	Cockle B., Lady Douglas I.	52° 29′ 128° 27′	Coarse black sand; kelp mats, *Zostera* LW level	12.0	26.6
H4	9	Baker Pt., Aristazabel I.	52° 48′ 129° 12′	Fine sand overlying coarse, at HW level igneous bedrock and fucoids, fine sand at LW level	–	–
H5	10	Hinks I., N end Aristazabel I.	52° 46′ 129° 19′	Bedrock pools at HW level, stone and boulder beach, kelp, and *Phyllospadix* at LW level	11.8	32.1
H6	10	Connis Cove, McCauley I.	53° 45′ 130° 18′	Mud, gravel, bedrock, fucoids. LW level	11.0	brackish
H7	11	Hankin Pt., McCauley I., cove at Beaver Pass entrance	53° 42′ 130° 24′	Fine sand at LW level, bedrock and boulders at MW level, kelp, *Zostera*	10.8	28.7
H8	11	Joachima B., N of Goshen I.	53° 49′ 130° 38′	Sand bottom, *Laminarians*, 10–20 ft. dredge	10.0	–
H9	11	Henry I., N end anchorage	54° 02′ 130° 42′	Stones and slate chips at HW level; FW stream mouth	–	–
H10	12	Oval B., inside George Pt.	53° 57′ 130° 42′	Fine ripple sand, below gravel, stone; *Phyllospadix* on bedrock. LW level; surf coast	11.5	30.5
H11	12	Qlawdzeet anchorage, Stephens I.	54° 13′ 130° 47′	Fine sand at HW level, muddy sand in MW seep	–	–
H12	13	Stephens I., NW end, surf shore	54° 11′ 130° 48′	Steep bedrock, boulders; *Ulva* and *Esteromorpha* at MW level, kelp and *Phyllospadix* at LW level	11.5	30.9
H13	14	Lelu I., NW end	54° 12′ 130° 18′	Fine dark sand flats, LW level. Bedrock and mud at MW level.	12.0	18.6

H14	14	Skeena estuary, opp. Inverness Pass	54° 08′ 130° 07′	Mud, 10–18 fm., trawl and dredge	11.5	nearly fresh
H15	15	Lawson Harbour, Lewis I.	54° 02′ 130° 15′	Fine mud + organic detritus, 20 ft. Ekman sample	11.0	–
H16	15	Georgy Pt., Kennedy I.	54° 10′ 130° 12′	Black mica sand, bedrock, kelp and fucoids, a few *Zostera* clumps, chips and detritus; LW level	11.2	22.0 brackish
H17	15	Off NW end Kennedy I.	54° 09′ 130° 12′	Muddy sand, leafy detritus, 10–20 ft. dredge	–	brackish
H18	16	Captain's Cove; NW end Pitt I.	53° 49′ 130° 11′	Gravel, stone, chips, coarse sand flats of estuary. LW–HW levels	–	brackish
H19	17	Captain's Cove; Pitt I.	53° 43′	Soft mud, 12–32 fm., trawl hauls	–	–
H20	17	N end McCauley I., Beaver Pass	53° 43′ 130° 22′	Protected fine sand beach at HW–MW levels	–	–
H21	17	Hecate Str., 1–2 mi. off N end Banks I.	53° 40′ 130° 34′	Fine shell, sand, coral, 20–30 fm. dredge	–	–
H22	17	½ mi. off Larsen H., Banks I.	53° 39′ 130° 34′	Sand, shell, kelp, 10 fm. dredge	–	–
H23	18	Deadman's Cove, Banks I.	53° 38′ 129° 28′	HW level—fine sand 10–15 ft. dredge	11.7	–
H24	18	Cox Pt., Trutch I.	53° 08′ 129° 45′	Bedrock, MW–HW pools. Surf coast. FW stream mouth	11.5	31.1
H25	19	Cox Pt. Inlet, at anchorage	53° 08′ 129° 45′	Muddy sand *Ulvacea*. 20 ft. dredge	–	–
H26	19	Cox Pt. Inlet, at mouth	53° 08′ 129° 45′	Shelly sand and kelp holdfasts, LW level	–	–
H27	19	Chapple Inlet, inside Holler Rock	52° 55′ 129° 08′	Muddy sand, shell, coral, glass sponges; 35 fm. dredge	–	–
H28	19	Holgate Pass, Emily Carr Inlet	52° 55.5′ 129° 09′	Dead shell, 11–24 fm. dredge	–	–
H29	20	Divided I., N of Chapple Sd.	52° 55′ 129° 09′	Coarse sand, stones, bedrock, *Ulvacea*, LW level.	14.2	14.8
H30	20	N end of Rennison I.	52° 51′ 129° 21′	Sand and kelp, 4–12 fm. dredge	–	–

Table 1. (Cont.)

Sta. No.	Date	Locality	Lat. and Long.	Habitat	T. ° C.	Sal'y. ‰
H31	July 20	Kitasu B., Swindle I.	52° 33′ 128° 48′	Hard sand, shells, 28–47 fm. dredge	–	–
H32	20	Willy Pt., Swindle I.	52° 34′ 128° 49′	Bedrock flats, surf pools, with *Spartina* and *Zostera*. HW–MW levels	–	–
H33	21	Higgins Passage, Kitt I.	52° 28′ 128° 46′	Surf exposed, bedrock, boulders, stones, shelly sand. LW–MW levels	13.8	28.4
H34	21	Pidwell Reef, Swindle I.	52° 27′ 128° 34′	Stones, shell, debris; 35 fm. dredge	–	–
H35	22	Koeye Estuary, Fitz Hugh Sd.	51° 47′ 127° 43′	Bedrock, restricted kelp, fucoids; steep coarse sand; HW–LW levels	13.2	var.
H36	22	Safety Cove, Calbert I.	51° 47′ 127° 43′	Black gravel, coral, shells; 15–42 fm. dredge	–	–
H37	22	Open Bight, mouth of Rivers Inlet	51° 23′ 127° 46′	Fine sand and shell; 25–35 fm. dredge	–	–
H38	22	W. beach, N side Smith Sd.	51° 20′ 127° 41′	Fine sand; HW level	–	–
H39	23	Dsulis anchorage, Smith Sd.	51° 20′ 127° 40′	Bedrock, boulders, fine sand, woody detritus; LW level	13.1	20.5
H40	26	Head of San Juan B., Port Renfrew, Vancouver I.	48° 33′ 124° 25′	Slate bedrock; fucoid and eel grass clumps. Black sand. LW level, sand at HW level	13.2	22.4
H41	27	Jordan R., Vancouver I.	48° 25′ 124° 02′	Black silty sand, stones, alga debris. LW level	11.2	31.5
H42	27	China Beach, Vancouver I.	48° 26′ 124° 04′	Fine sand beach at HW level; stream mouth	–	–
H43	28	Witty's Lagoon, Mechosin, V.I.	48° 23′ 123° 31′	Fine, soft, organic flat sand; LW level	12.0	–
H44	29	Brady's Beach, Bamfield, V.I.	48° 50′ 125° 09′	Fine white sand, bedrock; *Phyllospadix*, kelp; HW–LW levels	12.0	–

H45	29	Pachena B. Hd., Vancouver I.	48° 48′ 125° 07′	Fine sand flat beach under logs. MW–HW levels	–	–
H46	Aug. 4	Finis Nook, Boswell Inlet, Smith Sd.	51° 21′ 127° 30′	Protected bedrock, boulders. LW–MW levels	16.5	–
H47	5	Codfish Pass, Miles I.	52° 05′ 128° 19′	Coarse shelly sand, eel grass, kelp and alga mats, bedrock, boulders; LW level	12.5	30.1
H48	5	North Beach, Goose I.	52° 00′ 128° 25′	HW level—fine white sand. LW level—25 ft. dredge—sand, kelp, woody debris	–	–
H49	5	Goose I. anchorage	51° 56′ 128° 26′	Fine sand, shells, alga debris; 45 ft. grab	–	–
H50	6	Goose I., south beach	51° 56′ 128° 26.5′	Fine shell and sand, stones, *Zostera*, algae, rock; LW–HW levels	14.0	30.5
H51	6	Swan I., lagoon at head	51° 56′ 128° 28′	Fine sand, shell, boulders, fucoids, at at stream mouth; MW–HW levels	–	–
H52	6	Goose I., 1½ mi. off W coast	51° 58′ 128° 29′	Coarse sand, stones; 38 fm. dredge	–	–
H53	7	Townsend Pt., St. John Harbour	52° 12′ 128° 29′	Surf exposed bedrock, boulders, *Phyllospadix*, kelp, *Corallina*: LW–MW levels	14.2	30.3
H54	7	Dyer Cove, lagoon mouth, Athlone I.	52° 11′ 128° 27′	Stony shore, mouth of small stream; MW–HW levels	16.4	brackish
H55	7	Dyer Cove at fish camp anchorage	52° 11′ 128° 28′	Mud, shells; 60 ft. grab	–	–
H56a	8	Codville Lagoon, south arm King I.	52° 02.5′ 127° 52′	Gravel, mud, shells, *Zostera*, woody detritus; LW–MW levels	13.2	20.9
H56b	8	Codville Lagoon, at mouth	52° 03.5′ 127° 52′	Barnacle encrusted bedrock, shell, kelp; LW level		
H57	8	Cove off Nolan Pass, S end Hunter I.	51° 43′ 128° 05′	Gravel, mud, bivalve shells; LW–MW levels	–	–
H58	9	Hd. of Leckie B., Kildidt Sd.	51° 49′ 128° 06′	Bedrock, boulders, coarse sand, shell, *Phyllospadix*, woody detritus; LW level	13.7	26.8
H59	9	Off Bolivar I., W coast Calvert I.	51° 35′ 128° 08′	Fine, hard, white sand; 8 fm. grab	–	–

Table 1. (Conc.)

Sta. No.	Date	Locality	Lat. and Long.	Habitat	T. ° C.	Sal'y. ‰
H60	Aug. 9	Blackney I. beach, Calvert I.	51° 30' 128° 05.5'	Steep surf-exposed sand beach, under logs; HW level	–	–
H61	10	Kilbella B., River's Inlet	51° 42' 127° 21'	Silty sand, stones, fucoids; LW–MW levels	9.7	4.0
H62	10	Hd. of River's Inlet, mouth of Wannock R.	51° 41' 127° 15'	Muddy sand, detritus; 10–15 fm. grab	–	–
H63	10	Klaquaek Channel off Walham I.	51° 29' 127° 41'	Mud ooze; 44 fm. grab	12.5	–
H64	10	Klaquaek Channel, Schooner, retreat	51° 28' 127° 50'	Shelly mud; 25 fm. grab	–	–
H65	11	Christie Pass, cove on S side Hurst I.	50° 50' 127° 35'	Bedrock, stones, shelly gravel, kelp, detritus; LW–MW levels	9.8	31.5

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MANDIBULAR PORE PATTERN IN THE SCULPIN FAMILY COTTIDAE[1]

By D. E. McAllister

RÉSUMÉ

Le nombre et l'arrangement des orifices s'ouvrant sur le tube mandibulaire du système de la ligne latérale ont fait l'objet d'études chez les spécimens de plus de quatre-vingts espèces de chabots, ainsi que chez un représentant de chacun des vingt et un ordres de téléostéens. Parmi les constatations, on a remarqué (1) qu'il y a une tendance générale, mais très irrégulière, à une diminution du nombre des orifices mandibulaires depuis les espèces primitives jusqu'aux espèces plus évoluées des téléostéens; (2) que la disposition des espèces primitives pour la famille des cottidés était de 4–4; (3) que les petits téléostéens, tels que les gastérostéidés, les phallostéthidés et les gobiidés, peuvent perdre la paroi externe du tube et laisser exposer les cellules sensorielles; (4) que les chabots d'eau profonde peuvent développer des orifices agrandis; (5) que la disposition des orifices mandibulaires était souvent considérée comme un caractère utile chez la famille des cottidés au niveau spécifique et parfois générique.

SUMMARY

The number and arrangement of the pores opening from the mandibular canal of the lateral line system were studied in specimens of over eighty species of sculpins as well as in a representative of each of twenty-one orders of teleostomes. Findings included the following: 1) that there is a general but quite irregular tendency for mandibular pores to decrease in number from the primitive to more advanced teleostomes; 2) that the primitive pattern for the family Cottidae is 4–4; 3) that small teleosts such as Gasterosteidae, Phallostethidae, and Gobiidae may lose the outer wall of the canal, exposing the neuromasts; 4) that deep water sculpins may evolve enlarged pores; 5) that the pattern of the mandibular pores was frequently found to be a useful character in the family Cottidae at the specific and sometimes generic level.

INTRODUCTION

Mandibular pores are the openings on the lower jaw of the preoperculomandibular cephalic sensory canal. These pores are more easily seen than other cephalic sensory pores since they open on the flat light expanse of the lower jaw. Using an air jet even tiny pores can be seen.

Mandibular pores are a little-used character in cottid systematics. This character has been applied only in the genus *Cottus* (Robins and Miller, 1957; McAllister and Lindsey, 1961; Robins, 1961; Bailey and Bond, 1963; McAllister, 1964). None of the major systematic studies on the Cottidae, such as those by Taranets (1959), Bolin (1944, 1947), or Watanabe (1958, 1960), have employed mandibular pores.

Some studies on other families may be noted. Illick (1956) reported on North American Cyprinidae. Branson and Moore (1962) have recently published a very fine study on the *lateralis* components in the family Centrarchidae. The utility of mandibular pores in separating species of *Esox* is well established.

This paper describes the pores in a number of cottid genera and species for the first time. For convenience the cottid genera and species are listed

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[1] This paper was read at the June 1962 meeting of the American Society of Ichthyology and Herpetology.

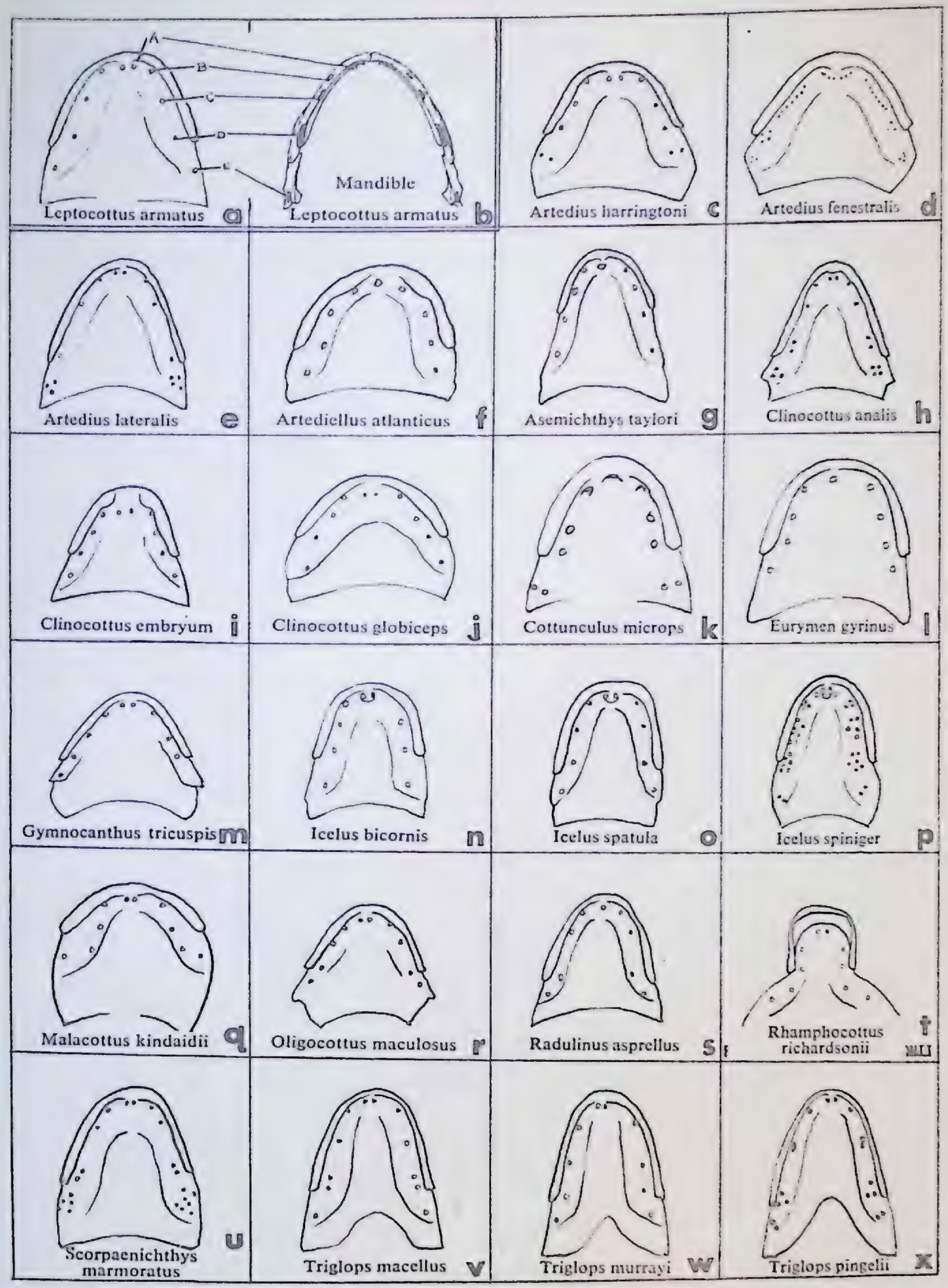

FIGURE 1—Mandibular pore patterns in the sculpin family Cottidae.

in Table 1 and appear on Figure 1 alphabetically. A brief review of mandibular pores in other cottoid families and several teleost orders is given as a background to this study. The taxonomic value and evolutionary significance of the mandibular pores is discussed.

MANDIBULAR PORES IN COTTIDAE

To facilitate discussion, the pores at different positions are named (*see* Figure 1 a). The anteriormost pore position is called A or mental; the second B; the third C; the fourth D (usually opposite the end of the maxillary). These are all encompassed in the dentary bone (*see* Figure 1b). The fifth position, E, the postmaxillary pore(s), is located in the angular (articular of some authors). The pore pattern can be expressed as a formula. The basic 4–4 formula may differ in three ways. The two mental pores may approach one another so closely that the intervening ridge disappears, and the pores become one. The consequent formula is 3–1–3. Secondly, more than one pore may appear at any of the pore sites A to D. Thirdly, pores may disappear. The postmaxillary pore may be absent, single, double, triple, or quadruple.

The following table, Table 1, presents the pore formulae for the different representatives of Cottidae, then for the representatives of other cottoid families examined. The figures on Figure 1 illustrate some of the variations encountered. In the table the mandibular formulae, the number of postmaxillary pores on a side, and the source (catalogue number of specimens or reference), number of specimens, and locality of the sample examined are presented. Neuromasts exposed on the skin are not, of course, counted as pores. Catalogue numbers preceded by NMC are those of the National Museum of Canada; those preceded by BC are of the Institute of Fisheries, University of British Columbia; and those preceded by USNM are of the United States National Museum. A dash under 'Postmax.' in the Table indicates this character was not examined.

Table 1—PORE FORMULAE IN DIFFERENT GENERA AND SPECIES OF COTTIDAE

Species	Formula	Post-max.	Cat. No.	No. Specimens	Source
COTTIDAE					
Abyssocottus gibbosus	16–17	7	NMC uncat.	1	Lake Baikal, USSR
Alcichthys alicornis	4–4	2	BC60–153	1	near Otaru, Japan
Artediellus atlanticus (fig. 1f.)	3–1–3	1	NMC uncat.	1	Saguenay R., P.Q.
Artediellus scaber	3–1–3	2	NMC60–476	2	17 miles west Herschel, Yukon
Artedius fenestralis A3, B7, C7, D3 or 4 (fig. 1d)	18–17	4	BC55–356	1	Vancouver, B.C.
Artedius harringtoni (fig. 1c)	4–4	2	BC53–119	1	Eagle Harbor, B.C.
Artedius lateralis	4–4	3 or 4	BC53–210	1	Gale Pass, B.C.
Aschelichthys rhodorus	3–1–3	1	BC57–210	1	Saturna I., B.C.
Asemichthys taylori (fig. 1g)	3–1–3	1	BC53–53	1	Vancouver, B.C.
Batrachocottus nikolskii	4–4	2	NMC uncat.	1	Lake Baikal, USSR
Blepsias cirrhosus	4–4	–	BC60–153	1	near Otaru, Japan

Table 1. (Cont.)

Species	Formula	Post-max.	Cat. No.	No. Specimens	Source
Chitonotus pugetensis	4–4	1	BC59–567	1	Strait of Georgia, B.C.
	4–4	1	BC53–265	1	Port Hardy, B.C.
Clinocottus analis D double (fig. 1h)	5–5	3 or 4	BC53–296	1	reef 2 miles north of San Simeon, Calif.
Clinocottus embryum (fig. 1i)	4–4	1	BC60–226	1	Brooke Peninsula, B.C.
Clinocottus globiceps (fig. 1j)	4–4	1	BC60–228	1	Brooke Peninsula, B.C.
Cottiusculus schmidti A double	5–5	2	–	–	after Watanabe (1960, fig. 62)
Cottocomephorus grewingkii	4–4	1–2	NMC uncat.	2	Lake Baikal, USSR
Cottunculus microps (fig. 1k)	3–1–3	2	NMC62–93	1	Southwest of Sable Island, N.S.
			NMC62–121	1	Grand Banks, Nfld.
Cottus asper, aleuticus, gobio, princeps, ricei, sibiricus, spinulosus	3–1–3	2(1)	–	–	Original data and literature in introduction
Cottus baileyi, bairdii, carolinae, confusus, echinatus, extensis, haitej, hubbsi, kesserli, kneri, klamathensis, poecilopus, rhotheus	4–4	1 or 2	–	–	Original data and literature in introduction
Cottus tenuis, asperrimus, gulosus, pittensis	4–4 or 3–1–3	1 or 2	–	–	Robins and Miller (1957), Bailey and Bond (1963)
Dasycottus setiger	4–4	1	NMC 60–501	2	Chemainis, B.C.
Enophrys diceraus	4–4	1	BC56–344–A	1	Japan and after Watanabe (1960, fig. 40)
Enophrys bison	4–4	1	BC59–579	2	Vancouver, B.C.
	4–4	–	NMC60–506	6	Vancouver, B.C.
	4–5	–	NMC60–506	3	Vancouver, B.C.
	5–6	–	NMC60–506	2	Vancouver, B.C.
	6–6	–	NMC60–506	1	Vancouver, B.C.
	6–7	–	NMC60–506	1	Vancouver, B.C.
	7–9	–	NMC60–506	1	Vancouver, B.C.
Enophrys lucasi	4–4	1	BC61–80	1	Chukchi Sea, Alaska
Enophrys claviger	4–4	1	NMC63–42	1	Alaska
Eurymen gyrinus (fig. 1l)	4–4	1	–	–	After Watanabe, (1960, fig. 70)
Gilbertidia pustulosa	4–4	1	–	–	After Schmidt, (1950, pl. xv)
Gymnocanthus galeatus	4–4	1	BC61–80	1	Chukchi Sea, Alaska
Gymnocanthus tricuspis	4–4	1	BC61–99	1	Chukchi Sea, Alaska
(fig. 1m)	4–4	–	NMC60–477	62	Southwest Herschel Island, Yukon
Hemilepidotus hemilepidotus	4–4	1	BC53–210	1	Gale Pass, B.C.
Hemilepidotus jordani	4–4	1	BC59–486	1	Uyak Bay, Alaska
	4–4	1	NMC uncat.	1	Alaska
Hemilepidotus spinosus	4–4	1	BC53–20	1	Vancouver, B.C.
Hemitripterus americanus	4–4	–	NMC62–97	1	Southwest of Sable Island, N.S.

Table 1. (Cont.)

Species	Formula	Post-max.	Cat. No.	No. Specimens	Source
Icelus bicornis A pores open into large common pit in *Icelus* (fig. 1n)	4–4	1	NMC60–476	1	7 miles northeast of Herschel Island, Yukon
Icelus spatula (fig. 1o)	4–4	1	NMC59–432	1	Ungava Bay, P.Q.
			BC61–101	1	Chukchi Sea, Alaska
Icelus spiniger 2 A pores, 2 B, 5–7C, 6 D (fig. 1p)	12–12 to 14–14	2	BC59–166	1	Off Hokkaido
Icelinus borealis	3–1–3	2	BC53–141	1	Vancouver, B.C.
	3–1–3	2	BC53–260	3	Friday Harbor, Wash.
	3–1–3	2	BC53–139	1	Georgia Strait, B.C.
Icelinus tenuis A single in 3, double in 1 specimen	3–1–3 or 4–4	1	BC53–73	1	Vancouver, B.C.
		1	BC53–81	1	Vancouver, B.C.
			BC53–211–A	1	Queen Charlotte Islands, B.C.
			BC53–125	1	Vancouver, B.C.
Leptocottus armatus (fig. 1a, 1b)	4–4	1	BC57–214	2	Saturna Island, B.C.
Malacottus kincaidii (fig. 1a)	4–4	1	BC53–77	1	Vancouver, B.C.
Megalocottus platycephalus	4–4	1	BC61–68	2	Chukchi Sea, Alaska
Myoxocephalus scorpioides	4–4	1 or 2	NMC60–57	2	Eric Cove, Ungava Bay,
			NMC60–186	2	South Flaherty Island, Northwest Territories
Myoxocephalus scorpius	4–4	2	NMC60–237	1	Gaspé Peninsula, P.Q.
			NMC59–393	5	Port Burwell, P.Q.
			NMC59–315	7	St. Andrews, P.Q.
Myoxocephalus aeneus	4–4	1	NMC59–284	1	Cavendish, P.E.I.
	4–4	1 or 2	NMC59–264	5	Cap-au-Renard, P.Q.
	4–4	1 or 2	NMC59–322	5	Northumberland Str., N.B.
Myoxocephalus polyacanthocephalus 4–4 in 6; 5–5 in 2 specimens where C double	4–4 or 5–5	4	BC57–205	3	Saturna Island, B.C.
			BC58–209	1	Afognak Island, Alaska
			BC60–413	5	Moresby Island, B.C.
Microcottus sellaris (5–5 where D double)	4–4	1	BC62–939	2	Alaska
	5–5	1		1	
Myoxocephalus octodecimspinosus pores tiny	3–1–3	1	NMC62–80	3	Southwest of Sable Island, N.S.
Myoxocephalus quadricornis pores tiny and hard to discern. 1 C pore, no B or D	1–1–1	–	NMC60–475	3	Herschel Island, Yukon
Myoxocephalus thompsonii pores apparently absent from papillose mandibles	0	0	NMC60–493–A	–	6 miles off Southampton, Ontario
Nautichthys oculofasciatus	4–4	2	BC59–109	1	Saturna Island, B.C.

Table 1. (Conc.)

Species	Formula	Post-max.	Cat. No.	No. Specimens	Source
Nautichthys pribilovius	4–4	2	BC61–87	1	Chukchi Sea, Alaska
Oligocottus maculosus	4–4	2	BC53–264	2	Vancouver, B.C.
(fig. 1r)	4–4	–	NMC60–499–A	32	Dionisio Point, B.C.
	4–4	–	NMC59–98	42	Vancouver, B.C.
Oligocottus rimensis	4–4	1	BC54–448	1	Saturna Island, B.C.
Oligocottus snyderi	4–4	1	BC53–228	1	Goose Island, B.C.
Procottus jeittelesi	15–16	6–7	NMC uncat.	1	Lake Baikal, USSR
Psychrolutes paradoxus	4–4	1	BC58–336	1	Friday Harbour, Washington
Radulinus asprellus	3–1–3	1	BC53–70	1	English Bay, B.C.
(fig. 1s)	3–1–3	1	NMC60–504	1	Chemainis, B.C.
Rhamphocottus richardsonii	4–4	1	BC53–229	1	Vancouver, B.C.
(fig. 1t)	4–4	1	NMC59–103	1	Burrard Inlet, B.C.
Scorpaenichthys marmoratus 2 D pores (fig. 1u)	5–5	5–7	BC60–238	1	Peach Bay Beach, Washington
Synchirus gilli	3–1–3	1	NMC61–128	2	Resurrection Bay, Alaska
Taurulus bubalis	4–4	0	BC56–93	1	Europe
Triglops macellus	5–5	1	BC53–83	1	Vancouver, B.C.
2 D pores (fig. 1v)	5–5	2	BC53–83	1	Vancouver, B.C.
Triglops murrayi (fig. 1w)	4–4	–	NMC62–94	1	Southwest of Sable Island, N.S.
	4–4	–	NMC61–214	1	52 miles south of Anticosti I., P.Q.
	4–4	1	NMC61–210	1	17 miles southeast of Perce, P.Q.
Triglops pingelii (fig. 1x)	6–6	2	NMC60–472	1	Southeast Herschel Island, Yukon
	7–5 and 7–9	2–4	NMC59–470	2	Frobisher Bay, Northwest Territories
	8–6	1	BC61–106	1	Chukchi Sea, Alaska
	9–9	1	BC53–1	1	Orca Island, Wash.
Ulca bolini	4–4	1	BC62- 642	1	Alaska
OTHER COTTOIDS, CYCLOPTEROIDS					
COMEPHORIDAE					
Comephorus dybowskii	3–1–3	1	NMC uncat.	1	Lake Baikal, USSR
SCORPAENIDAE					
Sebastodes caurinus	4–4	1	BC53–132	1	Port MacNeil, B.C.
Scorpaena guttata 2 B pores	5–5	1	BC53–292	1	Newport Bay, Calif.
TRIGLIDAE					
Prionotus carolinus	37–29	–	NMC62–73	1	North Carolina
AGONIDAE					
Aspidophoroides olrikii	4–4	1	NMC60–70	4	Evans Strait, N.W.T.
Leptagonus decagonus 2 D pores	5–5	1	NMC61–212	1	Chandler, P.Q.
Bathyagonus nigripinnis	3–1–3	1	BC57–53	1	Vancouver, B.C.
LIPARIDAE					
Liparis herschelinus	4–4	1	BC61–106	1	Chukchi Sea, Alaska

MANDIBULAR PORES IN OTHER FISHES

In the following table a very brief outline of pore variation in different orders is presented. Since it is only the briefest of reviews, the locale is not given, but if this should be required, it could be obtained by the catalogue number. *All* the mandibular pores, including the postmaxillary, are included in the total mandibular pore count, since in most of the lower groups the postmaxillary pores are not readily separable from the others. The ordinal classification follows McAllister (1967).

Table 2—TOTAL MANDIBULAR PORE COUNT IN DIFFERENT TELEOST ORDERS

Taxon	Total Mandibular Pore Count	No. Specimens	Source
Polypteriformes, Polypteridae: *Polypterus bichir*	9–9	–	Devillers (1958, fig. 701B)
Amiiformes, Amiidae: *Amia calva*	10–10	3	NMC58–209
Lepisosteiformes, Lepisosteidae: *Lepisosteus osseus*	13–15	1	NMC60–478–A
Clupeiformes, Clupeidae: *Dorosoma cepedianum*	6–6	2	NMC60–521–A
Salmonidae: *Salvelinus*	4–4 to 11–11		Morton and Miller (1954)
Esocidae: *Esox*	4–4 to 11–11		Trautman (1957)
Notacanthiformes, Notacanthidae: *Notacanthus phasganorus*	5–5	2	NMC62–123
Cypriniformes, Cyprinidae: *Notemigonus crysoleucas*	5–5	2	NMC60–10
North American Cyprinidae,	3–3 to 16–16	–	Illick (1956)
Ictaluridae: *Ictalurus nebulosus*	6–6	2	NMC60–10
Anguilliformes, Anguillidae: *Anguilla rostrata* (anterior 2 pores sink into a fold in adult)	7–7	2	NMC59–261
Mirapinniformes, Mirapinnidae, and Eutaeniphoridae	0	–	Bertelsen and Marshall (1956)
Cetomimiformes, Cetomimidae: *Gyrinomimus simplex*	8–8	–	Parr (1946)
Zeiformes, Zeidae: *Capromimus abbreviatus*	4–4	2	NMC64–834
Gadiformes, Gadidae: *Lota lota*	0	–	Devillers (1958)
Gadus morhua macrocephalus	7–7	3	NMC59–146
Microgadus, *Eleginus* *Boreogadus*, and *Arctogadus*	0	–	Svetovidov (1948)

Table 2. (Cont.)

Taxon	Total Mandibular Pore Count	No. Specimens	Source
Undescribed order, Brotulidae: *Brosmichthys marginatus* (+ neuromasts)	6–6	2	BC61–426
Ophidiidae: *Lepophidium*	6–6	–	Robins (1960)
Percopsiformes, Percopsidae: *Percopsis omiscomaycus* (pores open from large cavities)	4–4	2	NMC61–455
Aphredoderidae: *Aphredoderus sayanus*	5–5	–	Moore and Burris (1956, pl. II)
Atheriniformes, Cyprinodontidae: *Fundulus heteroclitus* 2A, 2D pores	6–6	2	NMC59–282
Atherinidae: *Menidia menidia*	5–5	2	NMC59–331
Phallostethidae: *Neostethus siamensis* (open groove)	0	1	BC62–968
Scomberesocidae: *Cololabis saira*	10–10	1	NMC60–312
Ophicephaliformes, Anabantidae: *Anabas testudineus*	5–5	1	BC59–497
Pleuronectiformes, Pleuronectidae: *Reinhardtius hippoglossoides* 2 A pores (as *Perca fluviatilis*)	6–6	1	NMC uncatalogued
Perciformes, Centrarchidae: (whole family)	5–5 to 6–6	–	Branson and Moore (1962)
Bathyclupeidae: *Bathyclupea argentata*	5–5	1	USNM 186317
Sciaenidae: *Equetes acuminatus*	3–1–3	1	NMC60–338
Aplodinotus grunniens	2–1–2	1	NMC60–473–A
Percidae: *Perca fluviatilis* 2 A pores	6–6	2	NMC59–195 and 196
Cottoidei:	2–1–2 to 5–1–5 and 5–5 to 34–34, usually 5–5 or 6–6		(*see* Table 1)
Zoarcidae: *Lycenchelys*	5–5	–	Andriashev (1955)
Elotridae: *Dormitator latifrons* (neuromasts only)	0	3	NMC59–182
Gasterosteiformes Gasterosteidae: *Gasterosteus aculeatus* 8–9 neuromasts on skin	0	6	NMC60–223
Tetraodontiformes, Balistidae: *Cantherines amphioxus*	0	1	NMC60–338
Mastacembeliformes, Mastacembelidae: *Macrognathus aculeatus*	7–7	1	BC59–532

Table 2 (Conc.)

Taxon	Total Mandibular Pore Count	No. Specimens	Source
Synbranchiformes, Synbranchidae: *Monopterus javanensis*	4–4	1	BC53–167
Lophiiformes, Lophiidae: *Lophius americanus*	0	1	NMC62–95
Ceratioidei, surface neuromasts	0	–	Bertelsen (1951)
Batrachoidiformes, Batrachoididae: *Porichthys notatus*	3–3	2	NMC59–99
Gobiesociformes, Gobiesocidae: *Gobiesox maeandricus*	3–3	3	NMC62–29

FUNCTION OF MANDIBULAR PORES

The lateral line system, including the mandibular portion of the preoperculo-mandibular sensory canal, functions in the detection of water currents and low frequency vibrations. The mandibular canal, one may deduce, is particularly concerned with feeding behaviour. The timing of mouth-opening in engulfing prey is critical. If the mouth is opened too soon, the drag will decrease the speed of the pursuer. If the mouth is opened too late, the opportunity of engulfing the prey may be lost. By detecting the strength and direction of signals from the fleeing prey, the mandibular pores assist the fish in opening the mouth at the right moment.

EVALUATION OF PORES AS A CHARACTER IN COTTIDAE

The taxonomic value of a character depends on how much it differs between and varies within taxa. The variability determines whether it is useful at higher levels such as the order and family, at low levels such as species and subspecies, or not at all. Because of inherent biological variability, characters may be of different value in different groups.

In studies of nine species of *Cottus* (mostly from British Columbia and using between 20 and 463 specimens per species), McAllister and Lindsey (1961) found that variation from the normal pattern for the species did not exceed 1.5 per cent (number with abnormal pattern/total sample x 100). From data in a study of California *Cottus* (Robins and Miller, 1957) the pore variation from the normal was calculated to range from 0 per cent in *princeps* to 8.2 per cent in *tenuis*, and in one species, *asperrimus*, it was 32 per cent. These variations involved the fusion of the two mental pores to form a single median pore or, more rarely, the separation of a median pore into two pores. The other pores were very constant. In most marine species studied here the pattern seemed to be more constant. For example, there were no variants from the 4–4 formula among 76 specimens of *Oligocottus maculosus* examined, nor among the 63 specimens of *Gymnocanthus tricuspis* examined. On the other hand, some marine forms, usually those having more than 4 pores per mandible, were variable. In *Enophrys bison* the number of pores per side varied from 4 to 9, in *Triglops pingelii* from 5 to 9—generally the more numerous the pores the greater the variability. However, even when pores vary within a species, the pores may still be used to distinguish it from some other species. One may therefore conclude that mandibular pores, like other characters, are more valuable in some groups than in others and that evaluation of the character must depend on examination of series of specimens in each taxon.

Robins (1961) erected *Cottus girardi* partly on the basis of mandibular pores. Savage (1962) found pores variable in *girardi* and synonymized it with *bairdii*. About twenty per cent of Robins's *girardi* had two mental pores, a supposed character of *bairdii*. However, in the identification of other species of *Cottus* (Robins and Miller, 1957; McAllister and Lindsey, 1961), the number of mental pores has been found to be a useful character. This character also has some value at the species-group level. The *gobio* species-group (*gobio*, *sibiricus*, *spinulosus*, and *ricei*) share a median mental pore, as well as a mediolateral lateral line and protruding preorbitals. Excepting members of the *asper* species-group, other species groups usually have a pair of mental pores. In this review, useful differences were found between species in the genera *Artedius* (Figure 1c–e), *Clinocottus* (Figure 1h–j), *Icelus* (Figure 1n–p), and *Triglops* (Figure 1v–x). In some cases, genera found to be closely related by other characters were also found to have similar mandibular pore patterns. Examples of this are *Cottunculus* and *Eurymen* (Figure 1k and l), *Asemichthys* and *Radulinus* (Figure 1g and s), *Antipidocottus* and *Icelinus* (*Antipidocottus* has a median mental pore and was probably derived from a common ancestor of *Icelinus*, according to Bolin, 1952.). Thus mandibular pores may be considered as potentially valuable at the generic level also. The size of the pores and their relative distance from one another are also useful characters.

EVOLUTION OF MANDIBULAR PORES

Study of pore pattern in Cottidae and related families indicates that the primitive pattern for the Cottidae is 4–4. From this basic formula other patterns have evolved by multiplication or loss of pores. Frequently the two mental pores approach one another so closely that the intervening ridge disappears, and they form a single median pore. This fusion appears to have occurred more than once in the family. Pores may be lost as in *Myoxocephalus octodecimspinosus*. In other forms several pores may arise where there was but one before, as in *Artedius fenestralis*.

The size of the pores may change in response to selective pressure. Under conditions of weak light the non-photic sensory systems may be selected for. In deeper water forms such as *Cottunculus* (Figure 1k) and *Zesticelus* the pores may increase in size. *Cottus ricei*, which lives under poorly lighted conditions deep in lakes or in muddy water, has large pores, compared to other species of *Cottus*. In the shallow-water arctic *Myoxocephalus quadricornis*, the preopercular canals have been lost and the neuromasts are exposed, mounted on filaments. This is doubtless an adaption to the lightless period of the long arctic night (similar filaments are found in deepsea fishes). This character proved to be a preadaption to its deep water lake descendant, *Myoxocephalus thompsonii*, which has developed even longer filaments (McAllister, 1961). Augmentation of pore size or loss of canal walls increases the sensitivity of the neuromasts, substituting for the loss of visual acuity.

There appears to be a general decrease in the number of mandibular pores as one ascends the phylogenetic tree of teleosts (*see* Table 2). The lower orders have about ten, the primitive acanthopterygians have about six, and the most highly evolved orders have three or even none. However, the tendency to decrease is quite irregular. Longer-jawed forms tend to have more pores. Fish with small adult size may lose the roof of the canal, thus exposing the neuromasts on the surface of the skin. This has happened in such groups as the Gobiidae, the Phallostethidae, and the Gasterosteidae. Myers (1958) found that very small fishes tend to reduce or suppress the lateral line on the body. This trend is also found in the lateral line canals on the head.

CONCLUSIONS

1. The pattern of the mandibular pores was frequently found to be a useful character in the family Cottidae at the specific and sometimes generic levels.
2. The primitive pattern for the family Cottidae is 4–4.
3. Deepwater forms may evolve enlarged mandibular pores.
4. There is a general, but quite irregular, tendency for mandibular pores to decrease in number up the phylogenetic tree of teleosts.
5. Small teleosts such as Gasterosteidae, Phallostethidae, and Gobiidae may lose the outer wall of the mandibular canal, exposing the neuromasts.

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NOTES ON MAMMALS OF SOUTHEASTERN YUKON TERRITORY AND ADJACENT MACKENZIE DISTRICT

By Phillip M. Youngman

RÉSUMÉ

Cette étude traite de l'écologie, de la distribution et de la taxonomie de quarante et une espèces de mammifères qu'on trouve dans le sud-est du Yukon et dans le district avoisinant du Mackenzie. Elle concerne aussi les nouvelles données de distribution marginale du *Sorex palustris navigator*, du *Lemmus sibiricus helvolus*, du *Microtus oeconomus macfarlani*, du *Martes pennanti* et de l'*Odocoileus hemionus*.

SUMMARY

Forty-one species of mammals from southeastern Yukon and adjacent Mackenzie District with new marginal distribution records for *Sorex palustris navigator*, *Lemmus sibiricus helvolus*, *Microtus oeconomus macfarlani*, *Martes pennanti*, and *Odocoileus hemionus* form the basis for this ecological, distributional, and taxonomic study.

INTRODUCTION

Several authors have reported on the mammals of southwestern Yukon (Cameron, 1952; Baker, 1951; Banfield, 1961), and Rand (1945) treated the mammals of the Canol Road in south-central Yukon Territory and southwestern Mackenzie District. Stone (1900) and Williams (1933) commented on some mammals from the Liard River in British Columbia and the Northwest Territories; however, little has been published on the mammals of southeastern Yukon and the adjacent Mackenzie District.

The earliest mammalogical observations in this region (Elton, 1935) are contained in letters by Robert Campbell, Factor of Hudson's Bay Company's Glenlyon House (Frances Lake Fort or post), written in 1843, in which he described hoary marmots, woodchucks, arctic ground squirrels, chipmunks, and muskrats in the Frances River – Liard River area. In 1943 Rand (1944) collected in southeastern Yukon Territory near Irons Creek and interviewed trappers from Toobally lakes, Yukon Territory. He also collected along the Alaska Highway in nearby British Columbia, as did J. R. Alcorn in 1948 (Baker, 1951).

The physiography and geology of much of the area concerned has been treated by Dawson (1889) and Bostock (1948); the climate by Kendrew and Kerr (1955); and the vegetation by Porsild (1951), Raup (1947), and Rowe (1959).

The present paper is an ecological, distributional, and taxonomic account of forty-one species of mammals from southeastern Yukon and the adjacent Mackenzie District. It is based on field notes, specimens collected, and sight records made during 1961 and 1963 by parties led by me, and on specimens collected by George G. Goodwin in 1937. Small collections made by O. Norris-Elye in 1942 and 1943, by D. R. Flook and P. M. Mann in 1953, and by Harry Snyder in 1952 are included, as are observations made by E. B. Owen, Stuart Blusson, Richard Morris, and Louis Pospisil.

During the early summer of 1937, George G. Goodwin, in company with Harry Snyder and A. J. Macnab, collected on the Liard and Nahanni rivers and at Glacier Lake, Mackenzie District. Between July 24 and July 29 they also collected at Ida Lake (= McPherson Lake), Yukon Territory.

On July 9, 1961, Gaston D. Tessier, Ronnie Chambers, and I flew from the Smith River airport in northeastern British Columbia to North Toobally Lake, Yukon Territory, where we collected until July 17. The Toobally Lakes are situated in densely forested plateau country made up of gently rolling uplands (Plate I A). The dominant trees are white spruce, balsam poplar, and lodgepole pine.

On June 10, 1963, Gaston D. Tessier, William A. Baker, Robert A. Fortier, and I drove north from Watson Lake, Yukon Territory, on the newly constructed Cantung Road leading to the Canadian Tungsten Mine in the town of Cantung on the Flat River, Mackenzie District, Northwest Territories. We collected along this road until July 1. Brief characterizations of the physiography and vegetation of collecting stations on the Cantung Road follow:

38 mi. NNW Watson Lake, Yukon Territory. Pelly Plateau region. Below timberline, 2,000 feet; sandy soil; tall white spruce.

Little Hyland River, 128 mi. N Watson Lake, Yukon Territory. Logan Mountains. Forest-tundra ecotone. From below timberline along river, 4,000 feet (Plate I B) to edge of timberline, 5,000 feet (Plate II A); white spruce, willow thickets, alpine fir.

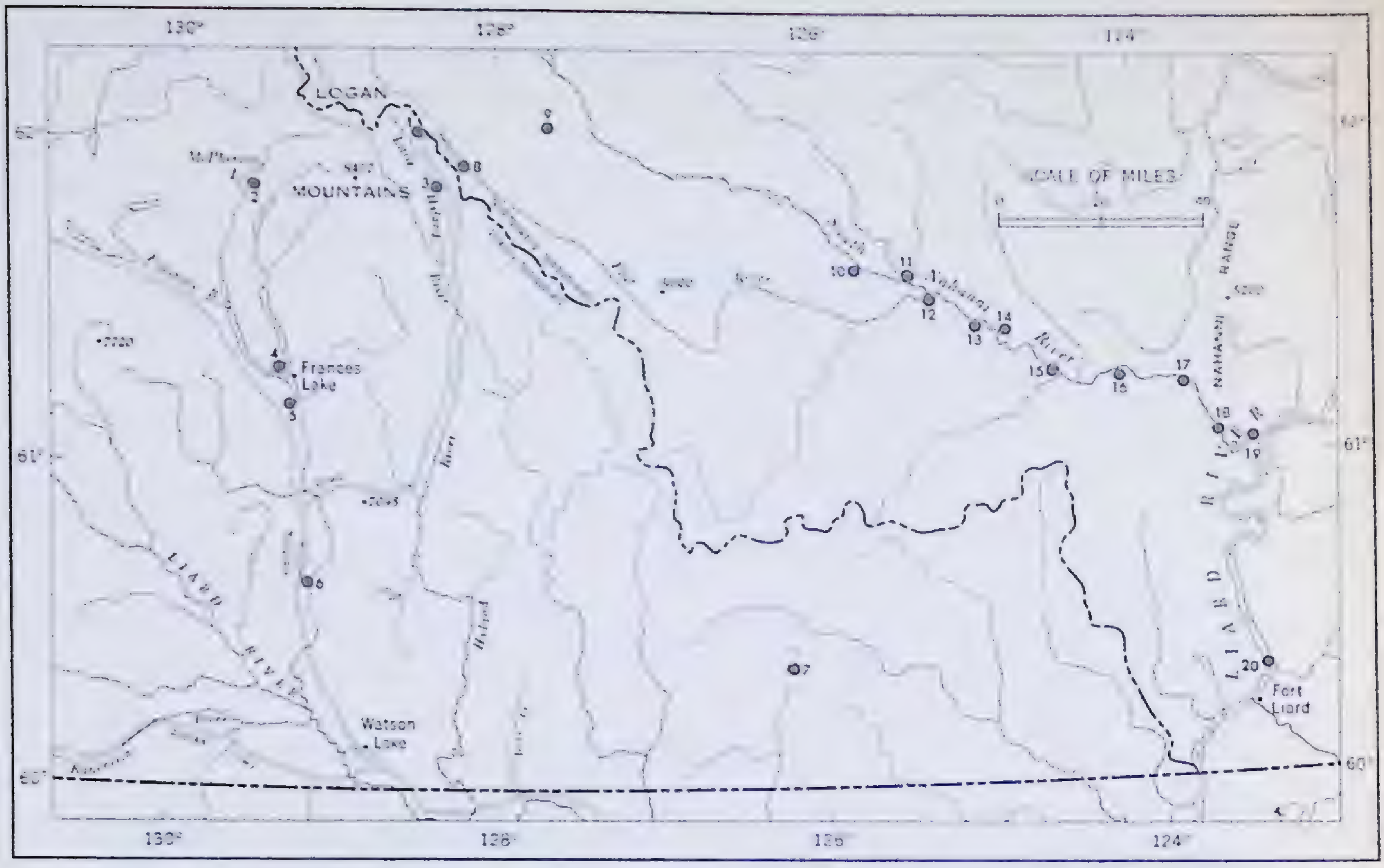
138 mi. N Watson Lake and 5 mi. E Little Hyland River, Yukon Territory. A pass through the Logan Mountains. Tundra, mostly above timberline, 6,000 feet (Plate II B).

Flat River, N.W.T., 134 mi. N Watson Lake, Y.T. Logan Mountains, below timberline, 4,000 feet. Hot mineral springs modify the microclimate and allow the development of a luxuriant growth of meadow vegetation surrounded by dense white spruce forest (Plate III A, B).

I have included some observations from a flight made over an extensive area north of Watson Lake in 1965.

Localities where specimens were collected are plotted on the map (Fig. 1) and listed in the legend. The specimens cited are in the National Museum of Canada (NMC) and the American Museum of Natural History (AMNH).

I gratefully acknowledge the field assistance of William A. Baker, Ronnie Chambers, Robert A. Fortier, and Gaston D. Tessier. Gaston Tessier also assisted in compiling data for this report. Richard G. Van Gelder and Karl Koopman kindly allowed me to examine specimens in their care and loaned me specimens from the American Museum of Natural History. George G. Goodwin provided information on localities for his collection. A. E. Porsild identified plants mentioned in this paper. The Map Compilation and Reproduction Division of the Department of Mines and Technical Surveys, Ottawa, produced map Figure 1.



Map Fig. 1—Map of southeastern Yukon Territory and southwestern Mackenzie District, Northwest Territories.

The following collecting localities are indicated by numbered black dots:

Yukon Territory

(1) 138 mi. N Watson Lake and 5 mi. E Little Hyland River

(2) Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T.

(3) Little Hyland River, 128 mi. N Watson Lake

(4) *Represented by a single dot*
Frances Lake, W arm
Frances Lake, 2 mi. up E arm
Frances Lake, near meteorological station
Frances Lake, E arm, 200 yd. SE post

(5) Frances River, 1 mi. S Frances Lake

(6) 38 mi. NNW Watson Lake

(7) North Toobally Lake (lat. 60°20′; long. 126°15′)

Mackenzie District, N.W.T.

(8) Flat River, 134 mi. N Watson Lake, Y.T.

(9) *Represented by a single dot*
Glacier Lake, Iron Mountain
Glacier Lake

(10) *Represented by a single dot*
Virginia Falls
Nahanni River, 3 mi. below Virginia Falls

(11) Nahanni River, Hells Gate

(12) Nahanni River, Flat River

(13) Mary River, Nahanni

(14) *Represented by a single dot*
Nahanni River, above Gates
Nahanni Gates

(15) *Represented by a single dot*
Nahanni River, Little Valley, 55 mi. above mouth S. Nahanni River

(16) *Represented by a single dot*
Nahanni River, hot springs
43 mi. above mouth S. Nahanni River
45 mi. above mouth S. Nahanni River

(17) 30 mi. above mouth S. Nahanni River

(18) *Represented by a single dot*
19 mi. above mouth S. Nahanni River
Jackfish River

(19) *Represented by a single dot*
2 mi. above mouth S. Nahanni River
1 mi. above mouth S. Nahanni River
Mouth S. Nahanni River
Forks Nahanni and Liard rivers
Near mouth S. Nahanni River

(20) Liard River, 12 Mile Island

SPECIES ACCOUNTS

Sorex cinereus cinereus Kerr—A male masked shrew (NMC 31138) was trapped in the hot springs meadow at Flat River, N.W.T., 134 mi. N Watson Lake, Y.T., 4,000 feet. Two males (NMC 31142, 43) were taken in wet grass and dwarf birch along the floodplain at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory, and at the same locality a nonparous female and a male (NMC 31144, 45) were taken in association with *Microtus longicaudus* on a stabilized talus slope at the base of a mountain. A male (NMC 31146) was taken in a stand of lodgepole pine 38 mi. NNW Watson Lake, 4,000 feet, Yukon Territory, and a nonparous female and a male (NMC 29390, 29400) were trapped at North Toobally Lake, 2,200 feet, Yukon Territory, in a dense white spruce muskeg near the edge of a lake.

Mann collected specimens (NMC A20665, 66) from 43 mi. above mouth S. Nahanni River and from 2 mi. above mouth S. Nahanni River, Northwest Territories.

Goodwin collected specimens from the following localities (all AMNH), Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., one (127970); Northwest Territories: Glacier Lake, 2,500 feet, thirty-one (127983–87; 127990–8000; 127961–65; 127971–75; 127977–79; 127981, 82); 3 mi. below Virginia Falls, 1,600 feet, three (12758–60); Nahanni Gates, 1,050 feet, one (121409); Nahanni River hot springs, two (127955, 57); Forks Nahanni and Liard rivers, five (121402–06); Liard River, 12 Mile Island, one (127954).

Sorex obscurus obscurus Merriam—A male dusky shrew (NMC 31155) was trapped at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory, at the base of a mountain in dry moss, lichens, and alder, with a few patches of willow. Three females and a male (NMC 31154, 31156–58) were trapped in a thick growth of dwarf birch and alder on dry ground. Two of the females trapped between June 12 and 17, 1963, were pregnant. One had nine embryos and the other ten. The other female had seven placental scars. Two nonparous females and a male (NMC 29398, 99, 401) were trapped at North Toobally Lake, 2,200 feet, Yukon Territory, in grass near a woodland stream.

Goodwin collected specimens from the following localities (all AMNH), Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., 4,000, 5,000 feet, four (127966–69); Northwest Territories: Glacier Lake, Iron Mountain, 2,500, 4,500 feet, ten (121407; 127956; 127976; 127980; 127988, 89; 127998; 128001–03); Glacier Lake, 2,500 feet, one (127980); Nahanni Gates, two (121407, 08); Nahanni River hot springs, one (127956).

The above specimens closely resemble topotypes in the United States National Museum.

Sorex palustris navigator (Baird)—Goodwin collected five water shrews (AMNH 127948–52) from a marsh at the upper end of Glacier Lake, 2,500 feet, Northwest Territories, between August 15 and 25, 1937. These specimens represent the second record of the species from Northwest Territories and are a northern marginal record of *S. p. navigator*.

Microsorex hoyi intervectus Jackson—A pigmy shrew (NMC 24116) from Frances Lake, Yukon Territory, collected by Norris-Elye, in February 1943, is the second specimen from the Yukon east of the Canol Road.

Ochotona princeps collaris (Nelson)—Two males and an immature nonparous female collared pika (NMC 31166–68) were shot 138 mi. N Watson Lake, 6,000 feet. One was collected in a rocky cliff in alpine tundra in association with *Eutamias minimus*, and another was taken in a talus slide. Three other specimens (NMC 31163–65), two males and a nonparous female, were shot in a talus slide at Little Hyland River, 128 mi. N Watson Lake, 4,000, 5,000 feet.

Goodwin collected pikas (all AMNH) from the following localities, Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W. Glacier Lake, N.W.T., 5,000, 6,000 feet, two (127805, 127807); Northwest Territories: Glacier Lake, Iron Mountain, 4,500 feet, three (127808–10); Nahanni River, above Gates, 4,500 feet, five (121388–92).

These specimens show no geographic variation.

Lepus americanus macfarlani Merriam—Varying hares were not seen at North Toobally Lake in 1961, nor on the Cantung Road in 1963. Goodwin collected three specimens (AMNH 127672–74) from Glacier Lake, 2,500 feet, Northwest Territories.

Marmota caligata (Eschscholtz)—Stewart Blusson saw hoary marmots in the vicinity of the pass on the Cantung Road in 1962 and 1963.

Flook collected a specimen (NMC A20603) from Nahanni River, near Brintnell Lake (= Glacier Lake), Northwest Territories.

Goodwin collected specimens (all AMNH) from the following localities, Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., 4,000, 5,000 feet, six (127743–48); Northwest Territories: Glacier Lake, Iron Mountain, 4,500 feet, eight (127740–42, 127749–53).

Eutamias minimus borealis (Allen)—Seven females and two males (NMC 31274, 31285–92) were collected 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,000 feet, Yukon Territory, in rocky cliffs in alpine tundra. This is the only locality in the Yukon where we have found chipmunks above treeline. One female had four placental scars, and another had five. A chipmunk was seen below treeline at the Tungsten mine at Flat River, N.W.T., 134 mi. N Watson Lake, Y.T., 4,000 feet. A female (NMC 31284) was collected at Little Hyland River, 128 mi. N Watson Lake, 5,000 feet, Yukon Territory, on the west-facing slope of a mountain in scrubby alpine fir. At this same locality, on June 15, a chipmunk was seen carrying nesting material in its mouth. Another chipmunk was seen 29 mi. NNW Watson Lake, Yukon Territory. In addition to the above records, Norris-Elye collected a male (NMC 19267) at Frances Lake, Yukon Territory, in 1943.

Two immature chipmunks (NMC 29494, 95) were collected, and several others were seen, on a relatively high rocky cliff at North Toobally Lake, 2,200–2,300 feet, Yukon Territory.

Mann collected a specimen (NMC A20667) from 30 mi. above mouth S. Nahanni River, Northwest Territories. Goodwin collected specimens (all AMNH) at the following localities, Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., one (127796); Northwest Territories: Glacier Lake, 2,500 feet, two (127797, 98); Nahanni River, Hells Gate, three (127793–95); Nahanni River, above Gates, 4,500 feet, one (121381); Northwest Territories: Forks Nahanni and Liard rivers, two (AMNH 121379, 80).

Spermophilus undulatus plesius Osgood—Arctic ground squirrels were comparatively few in number in the pass through the Logan Mountains; however two juvenile females (NMC 31242, 43) were collected at the mine at Flat River, N.W.T., 134 mi. N Watson Lake, 4,000 feet, and three juvenile females and an adult male (NMC 31266–69) were collected along the road through the pass and in higher rocky tundra 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 5,000, 6,000 feet, Yukon Territory. None of the females were pregnant; however one had four placental scars and another had three. A ground squirrel was also seen 29 mi. NNW Watson Lake, Yukon Territory.

Goodwin collected arctic ground squirrels (all AMNH) at the following localities, Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., sixteen (127716–31); Northwest Territories: Glacier Lake, 2,500, 4,500 feet, eight (127732–39).

Tamiasciurus hudsonicus (Erxleben)—A male and two female red squirrels (NMC 31229–31) were shot in white spruce at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory. One of the females had three placental scars. A male (NMC 19593) was taken by Norris-Elye, in 1943, at Frances River, 1 mi. S Frances Lake, Yukon Territory. Two females and a male (NMC 31232–34) were collected in lodgepole pine and white spruce, 38 mi. NNW Watson Lake, 2,000 feet, Yukon Territory. Fourteen male and nineteen female red squirrels (NMC 29421–52, 29842) were collected at North Toobally Lake, 2,200 feet, Yukon Territory, in dense white spruce.

Goodwin collected specimens (all AMNH) at the following localities, Northwest Territories: Glacier Lake, 2,500 feet, twenty-nine (127686–713, 127715); Nahanni River, Hells Gate, two (127684, 85); Nahanni River, Flat River, one (127683); Nahanni Gates, one (121417); Nahanni River hot springs, one (127682); Forks Nahanni and Liard rivers, nine (121412–16, 28992–95); Liard River, 12 Mile Island, 500 feet, four (127678–81).

Geographic variation in red squirrels in the northwest is poorly defined, and the group needs revision before subspecific assignment of the above mentioned specimens can be made.

Glaucomys sabrinus (Shaw)—A male northern flying squirrel (NMC 19592), collected by Norris-Elye in 1942, at east arm of Frances Lake, 200 yards SE of Post, Yukon Territory, is the only record for the Yukon east of the Canol Road.

Goodwin collected four specimens (AMNH 127772–75) from Glacier Lake, 2,500, 3,000 feet, Northwest Territories.

Castor fiber canadensis Kuhl—A subadult male beaver (NMC 31300) was shot 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,000 feet, Yukon Territory, in a lake above timberline, in the pass through the Logan Mountains. A large lodge and dam, both made of dwarf willow, were present. A beaver with two small young was observed June 22 at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory. In 1965 our party flew north from Watson Lake, over the Cantung Road, on a route that led to Norman Wells, Northwest Territories. Beavers were present in large numbers, especially along the Hyland and Little Hyland rivers, Flat River, and South Nahanni River, in alpine situations as well as below timberline. In 1961 beavers and cuttings were seen at North Toobally Lake, 2,200 feet, Yukon Territory.

Goodwin collected two specimens (AMNH 127769, 70) from Glacier Lake, 2,500 feet, Northwest Territories.

All specimens of beaver from the Yukon and Northwest Territories examined thus far are, on the basis of cranial characters, clearly referable to *C. f. canadensis* rather than to *C. f. belugae* Taylor.

Peromyscus maniculatus borealis Mearns—Seven male deer mice (NMC 24119–25) were collected at Frances Lake (vicinity of the meteorological station), Yukon Territory, by Norris-Elye in 1942 and 1943. Three males and a female (NMC 31326–29) were collected 38 mi. NNW Watson Lake, 2,000 feet, Yukon Territory, in white spruce and lodgepole pine and willow along the banks of a creek. A single male (NMC 29496) was collected near the shore of North Toobally Lake, 2,200 feet, Yukon Territory, in dense white spruce.

Mann collected twenty specimens (A20632–50, 70) from 55 mi., 45 mi., 43 mi., 19 mi., 2 mi., and 1 mi. above mouth S. Nahanni River, Northwest Territories.

Goodwin collected specimens (all AMNH) from the following localities, Northwest Territories: Glacier Lake, 2,500 feet, seven (127825–31); Nahanni River, Virginia Falls, 1,800 feet, one (127824); Nahanni Gates, 1,050 feet, two (121372, 73); Nahanni River hot springs, two (127822, 23); Forks Nahanni and Liard rivers, eight (121364–71); Liard River, 12 Mile Island, one (127819).

These specimens are assigned to *P. m. borealis* on the basis of short tail and colour.

Lemmus sibiricus helvolus (Richardson)—One male brown lemming (NMC 31371) was collected in a riparian tundra habitat 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,000 feet, Yukon Territory. Twenty-one males and eleven females (NMC 31341–57, 31359–70, 31373–75) were taken in muskeg at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory. Eight of the females had embryos (two contained 3, one 4, four 5, and one 6), and two had six placental scars each. On several occasions when setting traplines, field party members saw live lemmings.

The above specimens closely resemble the brilliantly coloured specimens from British Columbia and provide marginal northeastern records for the species.

Synaptomys borealis dalli Merriam—A male and a nonparous female northern bog lemming (NMC 31338, 31590) were collected in the hot spring meadow in association with *Microtus pennsylvanicus* and *Microtus longicaudus* at Flat River, N.W.T., 134 mi. N Watson Lake, Y.T., 4,000 feet. Specimens collected in Yukon Territory include a male (NMC 31372), in riparian bush tundra 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,000 feet; a male (NMC 31660), in similar habitat at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet; and eleven males and four females (NMC 29506–18, 29844, 45) in white spruce at North Toobally Lake, 2,200 feet.

Goodwin collected one specimen (AMNH 127924) from a marsh at the upper end of Glacier Lake, 2,500 feet, Northwest Territories.

The above specimens are assigned to *S. b. dalli* because they are paler than specimens of *S. b. borealis* from Wood Buffalo Park, Alberta, because they agree with the original description, and because they are indistinguishable from the Yukon assigned to *S. b. dalli* by Howell (1927).

Clethrionomys rutilus dawsoni Merriam—The northern red-backed mouse was trapped at all localities, in almost every kind of habitat, from 2,000 to 6,000 feet; however, its runways were never found in areas as wet as those occupied by *Microtus pennsylvanicus*. Specimens collected (all NMC) are as follows, Yukon Territory: 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,000 feet, three (31402, 04, 05); 128 mi. N Watson Lake, 4,000 feet, ten (31384–93); Frances Lake, near meteorological station, one (24118); 38 mi. NNW Watson Lake, 2,000 feet, six (31406–09; 31411, 12); North Toobally Lake, 2,200 feet, thirteen (29544–47, 29590–98); Northwest Territories: Flat River, 134 mi. N Watson Lake, Y.T., 4,000 feet, two (31376, 31410).

Mann collected eight specimens (NMC A20653–57, 61–63) from 2 mi. above mouth S. Nahanni River, Northwest Territories. Goodwin collected northern red-backed mice from the following localities (all AMNH), Northwest Territories: Glacier Lake, twelve (127838–49); Nahanni River, 3 mi. below Virginia Falls, 1,600 feet, one (127837); Nahanni Gates, 1,050 feet, four (121320–23); Forks Nahanni and Liard rivers, six (121314–19); Liard River, 12 Mile Island, one (127836).

Of twelve females taken on the Cantung Road, five had embryos (two contained 4, two 5, and one 6), and two had four and five placental scars respectively.

The above specimens show no geographic variation.

Ondatra zibethicus (Linnaeus)—Muskrats were seen on several occasions in the Little Hyland River, 128 mi. N Watson Lake, Yukon Territory, feeding on willow and horsetail. A muskrat was also seen at North Toobally Lake, Yukon Territory.

Microtus longicaudus vellerosus Allen—Three male long-tailed voles (NMC 31537–39) were collected in the hot springs meadow at Flat River, N.W.T. 134 mi. N Watson Lake, Y.T., 4,000 feet, N.W.T., in the same runways used by *Microtus pennsylvanicus*. Three males and two nonparous females (NMC 31520, 21; 31534–36) were taken in tundra 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,000 feet, Yukon Territory. Seven males and six females (NMC 31518, 31522–33) were collected at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory, on a stabilized talus slide at the base of a mountain. Four females collected between June 12 and 15, 1963, had embryos (one contained 3, two 4, one 5), and one had three placental scars.

Goodwin collected specimens (all AMNH) from the following localities, Northwest Territories: Glacier Lake, 2,500 feet, one (127911); Nahanni

River, Virginia Falls, two (127864, 66); Nahanni Gates, 1,050 feet, four (121344–46, 121348).

The above specimens closely resemble near topotypes from British Columbia.

Microtus oeconomus macfarlani Merriam—Northern voles were conspicuously absent from the hot springs area near the Cantung mine. Eight males and five females (NMC 31547, 31551–62) were collected in riparian bush tundra, 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 5,000 feet, Yukon Territory; and two males and a female (NMC 31548–50) were taken in similar habitat at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory. Three of the females, collected between June 18 and 28, 1963, had embryos (one contained 4, one 5, one 6) and two others had placental scars (6, 4).

Goodwin collected specimens (all AMNH) from the following localities, Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., 4,000–6,000 feet, sixteen (127887–90; 127892, 94; 127897–99; 127900, 01; 127903–07); Northwest Territories: Glacier Lake, Iron Mountain, 4,500 feet, seven (127915–21).

The above specimens all represent marginal southeastern records for the species.

Microtus pennsylvanicus drummondi (Audubon and Bachman)—Meadow voles were numerous in the hot springs meadow at Flat River, 134 mi. N Watson Lake, Y.T., 4,000 feet, Northwest Territories. During 87 trap nights (two nights of trapping), covering approximately four acres, 43 meadow voles were collected (31586–89, 31591–629). The hot springs meadow is ecologically isolated on all borders (Plate III A) so that this is indicative of the high population present. Numerous live voles were seen by members of the party.

The voles were utilizing the sedge *Carex aquatilis* for food and nests. Four males and one female (NMC 31673–77) were collected in a riparian sedge habitat 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,000 feet, Yukon Territory, in association with *Microtus longicaudus*, and thirty specimens (NMC 31644–59; 31661–72; 31678, 79) were taken in similar habitat at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory, in association with *Microtus oeconomus*. In 1943 a male (NMC 24117) was collected ¾ mi. N Frances Lake, Yukon Territory, by Norris-Elye. Of thirty-three females collected on the Cantung Road in 1963, sixteen were visibly pregnant, and the average number of embryos was 5.6 (4–8). Twenty-two males and twenty-two females (NMC 29766–809) were collected at North Toobally Lake, 2,200 feet, Yukon Territory, in white spruce, in association with *Synaptomys borealis* and *Clethrionomys rutilus*. Thirteen females were pregnant with an average number of embryos of 5.3 (3–7).

Goodwin collected specimens from the following localities (all AMNH), Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., 4,000–6,000 feet, sixteen (127886, 127891, 127893–900, 127902–07); Northwest Territories: Glacier Lake, 2,500 feet, forty-nine (127867–76, 127878–85, 127908–10, 127912–14, 127922–46); Nahanni River, Virginia Falls, 1,800 feet, five (127860–63, 127877); Nahanni Gates, 1,050 feet, five (121344–48); Nahanni River, Little Valley, one (127859); Nahanni River hot springs, five (127854–58); Forks Nahanni and Liard rivers, eleven (121333–43); Liard River, 12 Mile Island, one (127853).

Zapus hudsonius hudsonius (Zimmerman)—Two male meadow jumping mice (NMC 29825,26) were trapped in riparian sedge habitat at North Toobally Lake, 2,200 feet, Yukon Territory. These specimens closely resemble near topotypes of *Z. h. hudsonius* from Ontario.

Erethizon dorsatum myops Merriam—Neither porcupines nor their sign was seen by the 1961 and 1963 National Museum field parties; however, in 1937 Goodwin collected specimens (all AMNH) from the following localities, Northwest Territories: Glacier Lake, 2,500 feet, three (127765–68); Virginia Falls, one (127765).

Canis lupus Linnaeus—No wolves were seen by the 1961 and 1963 National Museum field parties; however, miners, truck drivers, and forestry officials informed us that during the winter wolves frequented the Cantung Road in large numbers. Trucks often hit one wolf after another at night. Men who surveyed the tungsten mine area before the road was built did not find wolves during the two winters prior to the opening of the road and thought that the road opened the country to large packs of wolves for the first time. During the winter of 1962–63 several 'hungry' wolves were seen lingering in the vicinity of the town, and steps were taken to protect the children.

Canis latrans Say—On July 14 and 16, 1961, coyotes were heard howling at night at North Toobally Lake, Yukon Territory.

Vulpes vulpes Linnaeus—A red fox was seen June 10, 1963, 41 mi. W Watson Lake, Yukon Territory, and another was seen on July 1, 1963, 10 mi. NNW Watson Lake, Yukon Territory.

Ursus americanus Pallas—A black bear was observed 118 mi. N Watson Lake, Yukon Territory, on June 15, 1963.

Snyder, Goodwin, and Flook each collected single specimens from the following localities in Northwest Territories: Brintnell Lake (= Glacier Lake), headwaters S. Nahanni River (NMC A20684); Glacier Lake, 2,500 feet (AMNH 127763); and mouth S. Nahanni River (NMC A20683).

Ursus arctos Linnaeus—Eleven sightings of grizzly bears were made on the northern end of the Cantung Road between June 10 and 22, 1963. A large female with a yearling cub was seen 126 mi. N Watson Lake, Yukon Territory. Several were seen in the high tundra near the pass; however, most sightings and sign were in muskeg and riparian habitat in the vicinity of Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory. At one place among large white spruce, on a well-drained knoll, I discovered a clearing obviously much used by bears. The clearing measured approximately 20 by 10 feet. On the heavily trampled moss forming the floor were a number of partly chewed beaver carcasses (undoubtedly left along the riverbank by trappers). On several occasions bears were seen at this spot.

Bears frequented the swampy floodplain of the Little Hyland River. On June 19, 1963, members of the party watched a grizzly rooting in the swamp. I wrote in my field notes, "The bear, walking in from a few inches to a foot of water, prowled back and forth looking for things to eat. At times it delicately dug at the sand with its long, light colored claws . . . it uprooted (willow) bushes and dug deeply. It found an old hide and tore off slimy chunks which it took to a dry place to eat. Often it lapped the hide. It found an old food box (wooden) and rooted at it, tipping it over and throwing it in the air." From a distance of thirty feet, we watched this individual for over an hour in heavy rain, but at no time did the bear appear to be conscious of our presence.

On June 20, 1963, at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory, two bears were observed walking north along the Cantung Road toward our camp. One of these, a female (NMC 31730), was unaware of my presence although it walked to within fifty feet of me.

Goodwin collected grizzlies at the following localities, Yukon Territory: Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., 4,000 feet, two (AMNH 127764, NMC 15392); Northwest Territories: Glacier Lake, 2,500 feet, one (AMNH 127764).

Mustela vison energumenos (Bangs)—Two mink were collected from Little Hyland River, 128 mi. N Watson Lake, 4,000 feet (NMC 31733, 38). Norris-Elye collected two specimens from Frances Lake, Yukon Territory. One (NMC 21954) from 2 mi. up east arm, 2,400 feet and another (NMC 21956) from west arm, 2,400 feet. Flook collected five specimens (NMC 25173–77) from Jackfish River, Northwest Territories. All these specimens are clearly referable to *M. v. energumenos* rather than to the larger *M. v. ingens* (Osgood). Hall and Kelson (1959, p. 917) plot a locality in southwestern Mackenzie as an extreme southern extension of the range of *M. v. ingens*. In their list of "marginal records" (p. 918) they document this locality as "Ogilvie Mts." in Mackenzie District, Northwest Territories; however the Ogilvie Mountains are in central Yukon Territory. Therefore a specimen from Fort Goodhope (NMC 32887) is the southernmost record for *M. v. ingens* in the Northwest Territories.

Mustela erminea richardsonii Bonaparte—According to local trappers, ermine are plentiful on the Cantung Road. On June 28, 1963, at Flat River, N.W.T., 134 mi. N Watson Lake, Y.T., 4,000 feet, I shot a female ermine (NMC 31732) as it dragged a Museum Special mouse trap holding a meadow vole. A female ermine (NMC 31734) was taken at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory; and two males (NMC 21953, 55) were taken by Norris-Elye at Frances Lake, Yukon Territory, during the summer of 1943.

Martes americana actuosa (Osgood)—The forested parts of the Cantung Road and Toobally Lakes regions are known to local trappers as good marten country. Two males and three females (NMC 31737, 38; 31740–43) were collected at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory.

Goodwin collected a specimen (AMNH 127771) at Glacier Lake, Northwest Territories.

Martes pennanti columbiana Goldman—In the Yukon, fishers are known to occur as far west as the Teslin area and as far north as Frances Lake.

The only known specimens from Yukon Territory are as follows: Morley Lake, 25 mi. SE Teslin, one (NMC 33351); 36 mi. W Watson Lake, one (NMC 33352); 35 mi. NW Liard Crossing, one (NMC 33353). These are northern marginal records of the species.

Gulo gulo Linnaeus—The National Museum field party saw an adult wolverine in a burned-over area on the Cantung Road, 129 mi. N Watson Lake, Yukon Territory, on June 10, 1963. Another was seen in high tundra, 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,000 feet, Yukon Territory.

Lutra canadensis (Schreber)—Flook collected a specimen (NMC A20674) from Northwest Territories: near mouth of South Nahanni River.

Felis concolor Linnaeus—There are numerous sight records of puma from the Yukon, south of Dawson. Some of these are undoubtedly authentic. Mr. Dick Morris, of Liard Crossing, an experienced hunter and trapper, saw a puma cross the Alaska Highway, 36½ mi. W Watson Lake, Yukon Territory, during the winter of 1964–65.

Felis canadensis (Kerr)—Tungsten Mines and Department of Public Works personnel informed me that lynx were numerous on the Cantung Road during the winter of 1962–63. The field party noted a road-kill 29 mi. NNW Watson Lake, Yukon Territory.

Goodwin collected two lynx (AMNH 127754, 55) at Glacier Lake, 2,500 feet, Northwest Territories.

Odocoileus hemionus (Rafinesque)—Mule deer build up in numbers in this region, but wolves kill them off when the snow is deep, according to Louis Pospisil of Liard Crossing. He saw mule deer in the following localities in Yukon Territory during 1964–65: Pelly Plateau; headwaters Frances River; 120 mi. up Liard (from Liard Crossing); McPherson Lake; and 45 mi. W Watson Lake.

E. B. Owen, of the Geological Survey of Canada, saw a mule deer at the mouth of the Flat River, South Nahanni River, Northwest Territories, in July 1964. Youngman (1964) referred a specimen from Lake Laberge, Yukon Territory, to *Odocoileus hemionus hemionus*.

Alces alces Linnaeus—Moose sign was abundant on the Cantung Road in 1963. There was an especially high density of moose in the vicinity of the hot springs at Flat River, N.W.T., 134 mi. N Watson Lake, Y.T., 4,000 feet, where five, including a cow with twin calves, were observed on several occasions feeding on *Carex aquatilis*. Moose were also observed at the following locations on the Yukon section of the Cantung Road: Little Hyland River, 128 mi. N Watson Lake, 4,000 feet; and 18 mi. N Watson Lake. On two occasions moose were observed eating willow. In 1965, our party, while flying north of Watson Lake, saw approximately fifty moose. This was more than seen during all other flights into other parts of the Yukon and the Northwest Territories.

Moose were abundant at North Toobally Lake, Yukon Territory, where their trails afforded the only good paths through the dense white spruce. Several moose were seen near camp including a cow and its calf. While flying over the Smith River inlet to South Toobally Lake on July 10, 1961, we saw ten bulls walking abreast against the current and feeding in shallow water.

Rangifer tarandus caribou (Gmelin)—Two caribou (NMC 31747, 48) were collected at Little Hyland River, 128 mi. N Watson Lake, 4,000 feet, Yukon Territory. Four caribou were seen on the Yukon section of the Cantung Road at the following localities: 138 mi. N Watson Lake and 5 mi. E Little Hyland River, 6,500 feet; Little Hyland River, 123 mi. N Watson Lake, 4,000 feet; and 55 mi. N Watson Lake. Two were browsing on willow.

Goodwin collected two specimens (AMNH 127761, 62) from Glacier Lake, Iron Mountain, 4,500 feet, Northwest Territories.

Oreamnos americanus (Blainville)—Mountain goats were seen by Stewart Blusson, of the Geological Survey of Canada, 124 mi. NNE Watson Lake. Y.T., Northwest Territories, during 1962–63.

Goodwin and Snyder collected two specimens (NMC 15390, 91) from Ida Lake (= McPherson Lake), 60 mi. W Glacier Lake, N.W.T., 4,500 feet, Yukon Territory; and three specimens (AMNH 127758–60) from Glacier Lake, Iron Mountain, 4,500 feet, Northwest Territories.

Ovis dalli dalli Nelson—Dalls sheep were often seen by miners in the vicinity of Flat River, N.W.T., 134 mi. N Watson Lake, Y.T.

Goodwin collected specimens from the following localities in Northwest Territories: Mary River, Nahanni, 4,000 feet, three (AMNH 128025–27); above the Gates, Nahanni River, three (NMC 14080–82); Snyder Mountains, Gates of Nahanni River, four (NMC 15386–89).

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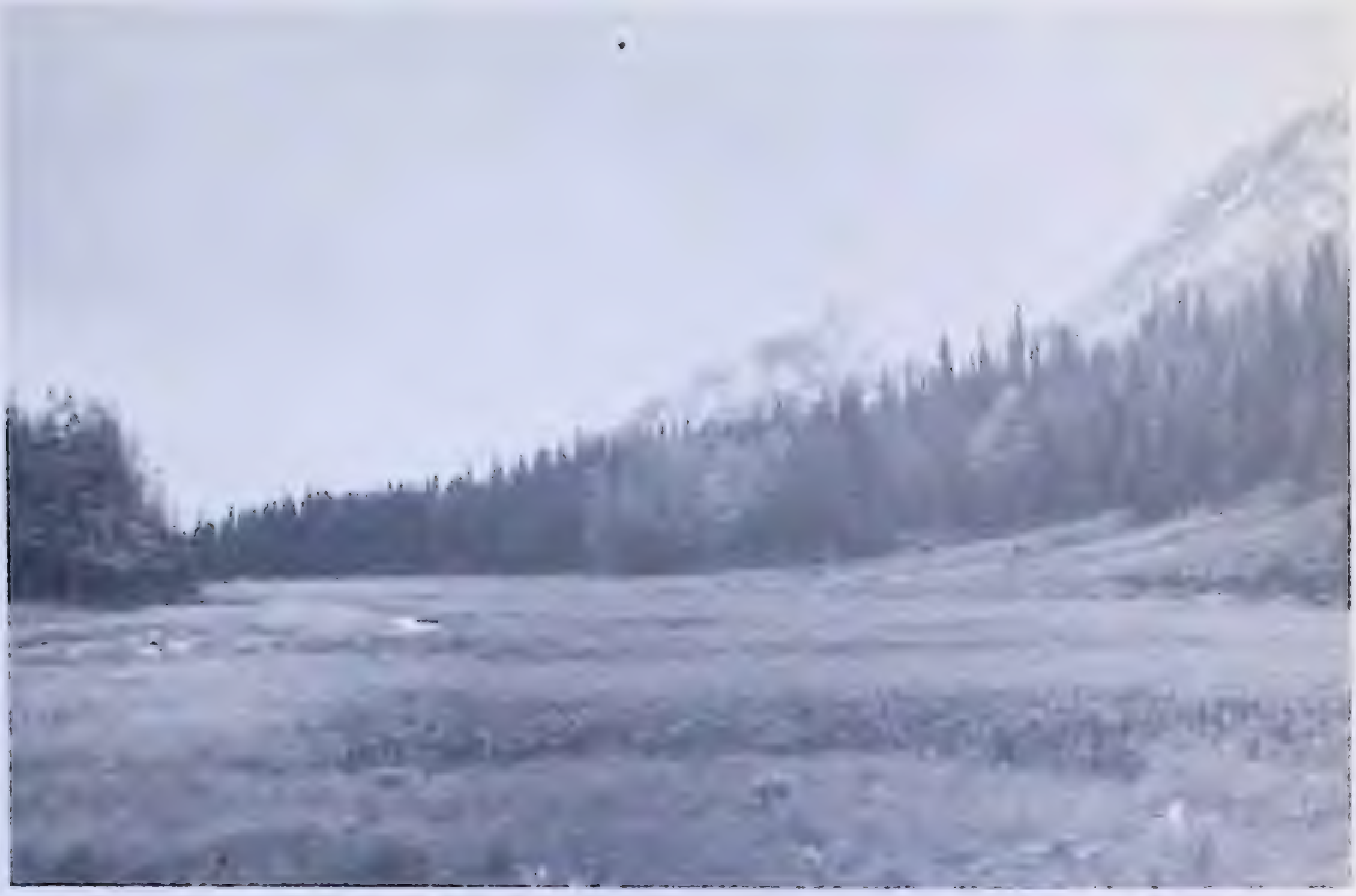
A. White spruce, balsam poplar, and lodgepole pine in the gently rolling plateau country surrounding North Toobally Lake, Y.T.

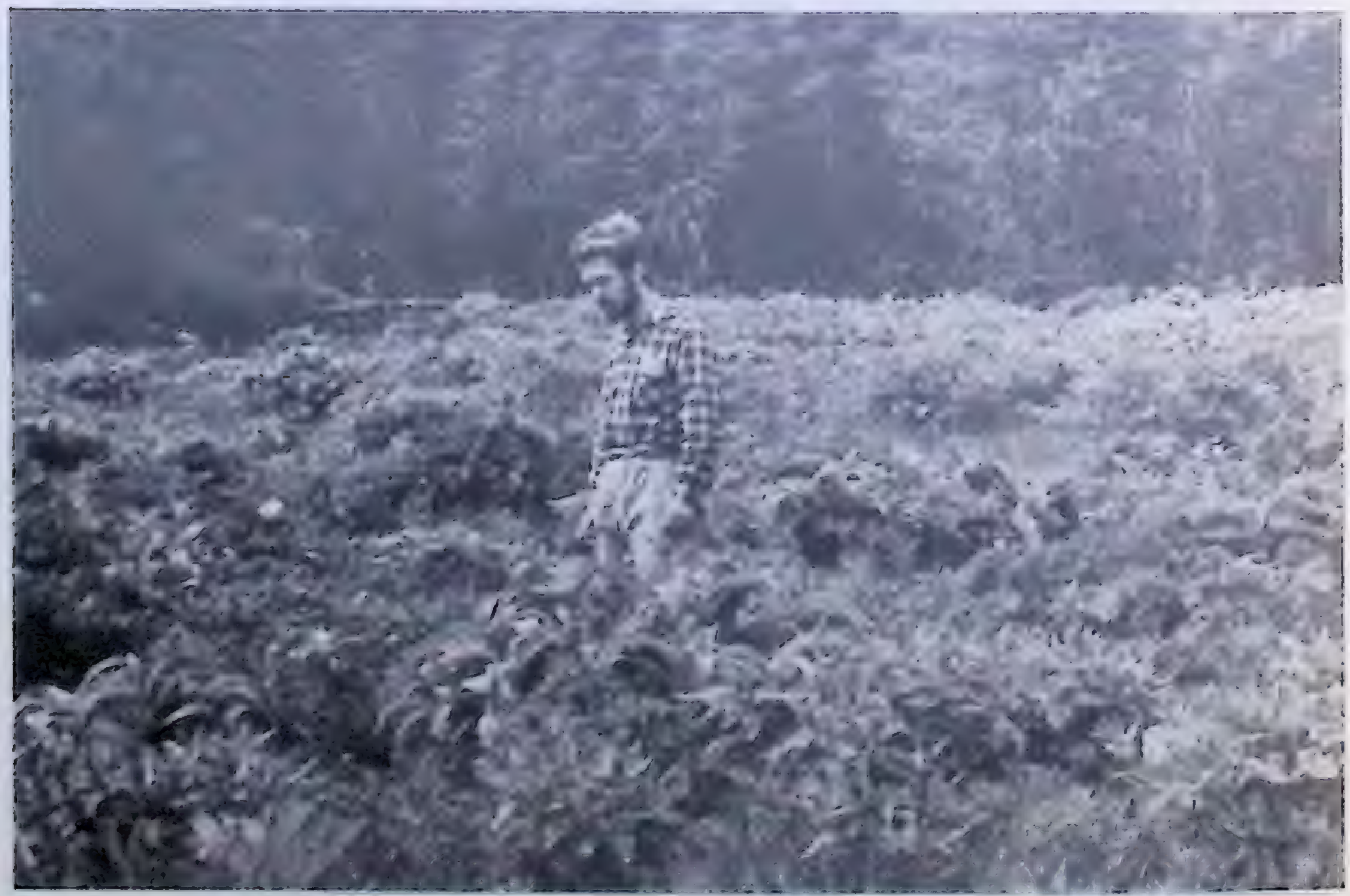
B. Dwarf birch, willow, and caribou moss along the edge of the Little Hyland River, 128 mi. N Watson Lake, Y.T., 4,000 feet.

A. Dwarf birch, white spruce, and caribou moss. Logan Mountains in the background. Little Hyland River, 128 mi. N Watson Lake, Y.T.

B. High tundra in the Logan Mountains, 138 mi. N Watson Lake and 5 mi. E Little Hyland River, Y.T., 6,000 feet.



A. Hot springs meadow surrounded by white spruce at the headwaters of the Flat River, N.W.T., 134 mi. N Watson Lake, Y.T.



B. Close-up view of hot springs meadow showing luxuriant growth of vegetation including *Veratrum Eschscholtzii*, *Heracleum lanatum*, and *Senecio triangularis*. Flat River, N.W.T., 134 mi. N Watson Lake, Y.T.